PB87-221032

Evaluation of Air Pollution Regulatory Strategies for Gasoline Marketing Industry - Response to Public Comments

(U.S.) Environmental Protection Agency
Research Triangle Park, NC

Jul 87

U.S. Department of Commerce
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Office of Air and Radiation
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Evaluation of Air Pollution Regulatory Strategies for Gasoline Marketing Industry —

Response to Public Comments

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16. ABSTRACT

The gasoline marketing industry (bulk terminals, bulk plants, service station storage tanks, and service station vehicle refueling operations) emit to the atmosphere several organic compounds of concern. These include: volatile organic compounds (VOC), which contribute to ozone formation; benzene, which has been listed as a hazardous air pollutant based on human evidence of carcinogencity; and gasoline vapors, for which there is animal evidence of carcinogencity. This document provides a summary of EPA responses to public comments on environmental and economic analysis published by EPA in 1984 (EPA-450/3-84-012a and b). Changes made to EPA's 1984 analysis in response to public comments, additional analyses performed, and a summary of the results are contained in a separate two-volume draft Regulatory Impact Analysis document (EPA-450/3-87-001 a and b).

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Evaluation of Air Pollution Regulatory Strategies for Gasoline Marketing Industry —

Response to Public Comments

OFFICE OF AIR QUALITY PLANNING AND STANDARDS
AND
OFFICE OF MOBILE SOURCES

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Radiation
Washington DC 20460
July 1987

1A

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1.0 INTRODUCTION

On August 8, 1984, EPA published in the Federal Register (49 FR 31706) notice of the availability of a document evaluating regulatory strategies being considered for controlling air pollutant emissions from the gasoline marketing industry (I-A-55). Public comments were solicited and over 180 individual comment letters were received. The purpose of this document is to respond to all of the major comments made by the public. Due to the volume of comments received, EPA could not respond to each comment letter or comment on an individual basis. Thus, to facilitate responding, the comments have been summarized and combined together under the following subject categories:

Chapter 2 - Onboard Controls
Chapter 3 - Stage II Controls
Chapter 4 - Tradeoffs Between Stage II and Onboard
Chapter 5 - EPA's 1984 Control Strategy Evaluation
Chapter 6 - Reasonableness of Control Costs Versus Health Risk Reduction
Chapter 7 - Stage I Controls
Chapter 8 - Effects on State Implementation Plans
Chapter 9 - Exposure/Risk Analysis
Chapter 10 - Other Methodologies and Considerations

Some of these categories reflect topic areas upon which the Agency specifically requested comment in the 1984 Federal Register Notice; these specific categories are denoted by an asterisk on the section title and a footnote saying "1984 Federal Register topic". The list of public commenters on the 1984 Federal Register notice and analysis document and the EPA docket item number assigned to each comment submittal are shown in Table 1-1.

Changes made to EPA's 1984 analysis in response to public comments, additional analyses performed, and a summary of the results are contained in a separate two-volume draft Regulatory Impact Analysis document.[1]

Table 1-1. LIST OF COMMENTERS ON EVALUATION OF REGULATORY STRATEGIES FOR THE GASOLINE MARKETING INDUSTRY

Item Number in Docket A-84-07	Date of Correspondence	Commenter and Affiliation
I-H-1[a]	8-21-84	Mr. Roger F. Dreyer Executive Vice President Ohio Petroleum Marketers Assoc., Inc. 50 West Broad Street, Suite 1130 Columbus, Ohio 43215
I-H-2	8-16-84	Ms. Jutta Schildknecht BMW of North America, Inc. Montvale, New Jersey 07645
I-H-3	8-16-84	Mr. Raymond J. Grubbe Senior Engineer AT&T Teletype Corporation 5555 Touay Avenue Skokie, Illinois 60077
I-H-4	8-24-84	Mr. Warren Cohen, President American Car Wash Corp. 7333 Little River Turnpike Annandale, VA 22003
I-H-5	9-13-84	Mr. Walter R. Quanstrom General Manager Standard Oil Company 200 East Randolph Drive Chicago, Illinois 60601 (Extension requested)
I-H-6	5-8-83	Mr. Earl Harris Matheny Box 195 R.R. #1 Stanford, KY 40484
I-H-7	3-13-84	Viola Amos 614 Riverside Drive Holly Hill, FL 32017
I-H-8	2-28-84	Mr. Wilfred Szerenyi 15700 Olive Branch Drive La Mirada, CA 90638
I-H-9	9-24-84	Mr. Milton Feldstein Bay Area Air Quality Management District 939 Ellis Street San Francisco, CA 94109 (Extension requested)

[a] Appendix A to this letter contains letters from 32 Ohio petroleum marketers, designated in this document as items I-H-1A1 through I-H-1A32.

Table 1-1. LIST OF COMMENTERS ON EVALUATION OF REGULATORY STRATEGIES FOR THE GASOLINE MARKETING INDUSTRY (continued)

Item Number in Docket A-84-07	Date of Correspondence	Commenter and Affiliation
I-H-10	9-25-84	Mr. James D. Boyd Air Resources Board 1102 Q Street P.O. Box 2815 Sacramento, CA 95812 (Extension Requested)
I-H-11	9-26-84	Mr. Jim Stokes, President Greater Washington/Maryland Service Station Association 9200 Edmonston Road, Suite 304 Greenbelt, MD 20770
I-H-12	10-1-84	J.C. Emmart Emmart Oil Co. P.O. Box 2247 Winchester, VA 22601
I-H-13	10-1-84	Robert J. Cutler, President Energy Retailers, Inc. P.O. Box 151 Hingham, MA 02043
I-H-14	10-1-84	Mr. W. G. Lyden, Jr. Lyden Oil Company P.O. Box 1854 Youngstown, OH 44501
I-H-15	10-2-84	Mr. William R. Deutsch Illinois Petroleum Marketers Association P.O. Box 1508 Springfield, IL 62705
I-H-16	10-1-84	Mr. Cliff Brice Cliff Brice Stations, Inc. 300 Moffat Avenue Pueblo, CO 81003
I-H-17	10-2-84	Mr. C.D. Bolton Bolton Oil Company P.O. Box 397 Artesia, NM 88210
I-H-18	9-28-84	Mr. Wayne Binsted Binsted's Exxon Service Center 4812 MacArthur Blvd., N.W. Washington, D.C. 20007

Table 1-1. LIST OF COMMENTERS ON EVALUATION OF REGULATORY STRATEGIES FOR THE GASOLINE MARKETING INDUSTRY (continued)

Item Number in Docket A-84-07	Date of Correspondence	Commenter and Affiliation
I-H-19	10-1-84	Mr. C.A. Fink BAR-F Enterprises, Inc. P.O. Box 129 Farmington, NM 87499
I-H-20	10-5-84	Mr. R.G. Roop Petroleum Marketers, Inc. 1603 Santa Rosa Road Richmond, VA 23288
I-H-21	10-8-84	Mr. George P. Ferreri, Director Air Management Administration Dept. of Health & Mental Hygiene 201 West Preston Street Baltimore, MD 21201
I-H-22	10-4-84	Mr. Kenichi Chiku Executive Vice President Toyota Technical Center, U.S.A., Inc. Ann Arbor Branch Ann Arbor, IL 48105
I-H-23	10-8-84	Mr. Michael J. Dougherty Manager, Environmental Control Union Oil Co. of California Box 7600 Los Angeles, CA 90054
I-H-24	10-8-84	Mr. Peter W. McCallum Corporate Environmental Specialist The Standard Oil Company Midland Building Cleveland, OH 44115
I-H-25	10-4-84	Mr. Mike Hawkins, President Hawk Oil Company P.O. Box 1388 1050 So. Riverside Medford, OR 97501
I-H-26	10-2-84	Mr. Dave Fellers, CAE Executive Vice President Texas Oil Marketers Association 701 W. 15th Street Austin, TX 78701

Table 1-1. LIST OF COMMENTERS ON EVALUATION OF REGULATORY STRATEGIES FOR THE GASOLINE MARKETING INDUSTRY (continued)

Item Number in Docket A-84-07	Date of Correspondence	Commenter and Affiliation
I-H-27	10-4-84	Mr. Doug Burton, Sales Manager McGill Incorporated P.O. Box 9667 Tulsa, OK 74157-96667
I-H-28	10-4-84	Mr. Braxton Hablof 2507 Central Avenue Alexandria, VA 22302
I-H-29	10-4-84	Mr. Stephen J. Powers, Jr. President Maine Oil Dealers Assoc. P.O. Box 536 Yarmouth, ME 04096
I-H-30	10-5-84	Mr. Herman L. Brummett Apollo Oil Company 1200 W. Pioneer Parkway Peoria, IL 61615
I-H-31	10-4-84	Mr. W. H. Hartley, President The Hartley Company 319 Wheeling Avenue Cambridge, Ohio 43725
I-H-32	10-3-84	Mr. F.W. Englefield Chairman of the Board Englefield Oil Company 447 James Parkway Newark, OH 43055
I-H-33	10-3-84	Mr. Don M. Ward Executive Vice President North Carolina Oil Jobbers Assoc. P.O. Box 30519 Raleigh, NC 27622
I-H-34	10-8-84	Mr. Gerald E. Wagner, President Convenient Remote Services P.O. Box 35580 Louisville, KY 40232
I-H-35	10-8-84	Mr. A. Tab Williams, Jr., President A.T. Williams Oil Company P.O. Box 7287 Winston Salem, NC 27109
I-H-36	10-6-84	Mr. Myron T. Holman, President Gas Pumpers of America Corp. Number One Valley Street Corner Braen Avenue & Valley St. Hawthorne, NJ 07506

Table 1-1. LIST OF COMMENTERS ON EVALUATION OF REGULATORY STRATEGIES FOR THE GASOLINE MARKETING INDUSTRY (continued)

Item Number in Docket A-84-07	Date of Correspondence	Commenter and Affiliation
I-H-37	10-8-84	Mr. Thomas N. Allen, President East Coast Oil Corporation 1420 East Commerce Road Richmond, VA 23224
I-H-38	10-5-84	Mr. Gus Fleischli Fleischli Oil Company P.O. Box 487 Cheyenne, WY 82003
I-H-39	10-8-84	Mr. Tendle L. Jones, Ptr. Jones Oil Company 402 East First Street Dehli, LA 71232
I-H-40	10-5-84	Mr. Francis C. Haviland Executive Director Fuels Merchants Association of New Jersey Gasoline Jobbers Division P.O. Box 359 Springfield, NJ 07081
I-H-41	10-5-84	Mr. Michael Kirschner Kirschner Bros. Oil Company Marketers of Petroleum Products 569 W. Lancaster Avenue Haverford, PA 19041
I-H-42	10-9-84	Mr. R.E. Germer, Vice President Flying, Inc. P.O. Box 678 Brigham City, UT 84302
I-H-43	10-9-84	Mr. David C. Waddell, Director Supply and Transportation Farmers Union Central Exchange, Inc. (CENEX) P.O. Box 43089 St. Paul, MN 55164
I-H-44	10-8-84	Mr. Don W. Myers, Sr. Chairman of The Board Swifty Oil Company, Inc. P.O. Box 1002 Seymour, IN 47274

Table 1-1. LIST OF COMMENTERS ON EVALUATION OF REGULATORY STRATEGIES FOR THE GASOLINE MARKETING INDUSTRY (continued)

Item Number in Docket A-84-07	Date of Correspondence	Commenter and Affiliation
I-H-45	10-5-84	Joseph R. Saxon, President and Chief Executive Officer Crystal - U.S.A. Oil, Inc. P.O. Box 9128 Birmingham, AL 35213
I-H-46	10-8-84	Mr. Robert T. Welsh, Jr. Welsh Oil, Inc. P.O. Box 10725 Merrillville, IN 46411
I-H-47	Undated	Mr. David Maybelef Mango Distributing Company P.O. Box 69 Barnhart, MO 63012
I-H-48	10-4-84	Mr. Arthur Goldstein Petrol Plus of Naugatuck, Inc. P.O. Box 492 Derby, CT 06418
I-H-49	10-7-84	Mr. Richard M.L. Oxterman Director of Development Lockie Lee Services, Inc. 310 Chester Street Painesville, OH 44077
I-H-50	10-5-84	Mr. J. Terry Ross Musket Corporation P.O. Box 26210 Oklahoma City, OK 73126
I-H-51	10-10-84	Mr. Thomas D. Hughes, President Pride Petroleum Company, Inc. P.O. Box 955 St. Charles, IL 60174
I-H-52	10-8-84	Mr. Reggie Dupree, President Cajun Energy, Inc. P.O. Box 878 Opelousas, LA 70570
I-H-53	10-8-84	Mr. Wataru Hayashibara, Manager Certification Business Division MAZDA (North America), Inc. 24402 Sincola Court Farmington Hills, MI 48018

Table 1-1. LIST OF COMMENTERS ON EVALUATION OF REGULATORY STRATEGIES FOR THE GASOLINE MARKETING INDUSTRY (continued)

Item Number in Docket A-84-07	Date of Correspondence	Commenter and Affiliation
I-H-54	10-8-84	Mr. Roy A. Turner Executive Vice President Colorado - Wyoming - New Mexico Petroleum Marketers Assoc. 4465 Kipling, Suite 104 Wheat Ridge, CO 80033
I-H-55	10-8-84	Mr. Maury S. Guttman Executive Vice President Guttman Oil Company Speers Road Belle Vernon, PA 15012
I-H-56	10-9-84	Mr. Shack Wimbish, Jr. Colonial Oil Industries, Inc. North Lathrop Avenue Savannah, GA 31402
I-H-57	10-9-84	Mr. William T. Burkhart Regional Air Pollution Control Agency 451 W. Third Street P.O. Box 972 Dayton, OH 45422
I-H-58	10-8-84	Mr. J.A. Stuart Executive Officer South Coast Management District 9150 Flair Drive El Monte, CA 91731
I-H-59	10-5-84	Mr. Robert L. French Executive Vice President California Target Enterprises, Inc. 12739 Lakewood Blvd. Downey, CA 90242
I-H-60	10-5-84	Mr. William Reilly City of Philadelphia Department of Public Health 500 S. Broad Street Philadelphia, PA 19146
I-H-61	10-9-84	Mr. W. Carey Johnson EZ-Go Foods, Inc. P.O. Box 286 Lawton, OK

Table 1-1. LIST OF COMMENTERS ON EVALUATION OF REGULATORY STRATEGIES FOR THE GASOLINE MARKETING INDUSTRY (continued)

Item Number in Docket A-84-07	Date of Correspondence	Commenter and Affiliation
I-H-62	10-12-84	Mr. Jimmy Harrell Inland Southwest Georgia Oil Company, Inc. 1711 E. Showell P.O. Box 1510 Bainbridge, GA 31717
I-H-63	10-10-84	Mr. James A. Haslam, II President Pilot Oil Corporation P.O. Box 10146 Knoxville, TN 37939-0146
I-H-64	10-9-84	Mr. Bill Hall Independent Oil Men's Assoc. of New England 25 Sea Breeze Lane New Castle, NH 03854
I-H-65	10-9-84	Mr. James M. Lents, Director Air Pollution Control Division Colorado Department of Health 4210 E. 11th Avenue Denver, CO 80220
I-H-66	10-9-84	Mr. R.S. Ivey, Treasurer Apollo Oil Company 1200 W. Pioneer Parkway Peoria, IL 61615
I-H-67	10-16-84	Mr. W.B. Beaver Executive Vice President Southern Pumps & Tank Company P.O. Box 31516 Charlotte, NC 28231
I-H-68	10-12-84	Mr. Randy Castleberry The Pantry, Inc. P.O. Box 1410 Sanford, NC 27330
I-H-69	10-10-84	Mr. Bill Corning, President Winn Brothers, Inc. P.O. Box 441 Weatherford, OK
I-H-70	10-7-84	Mr. Gil Arnold, President Road Runner - Arnold Dist. Co. South Robison Road P.O. Box 973 Texarkana, TX 75501

Table 1-1. LIST OF COMMENTERS ON EVALUATION OF REGULATORY STRATEGIES FOR THE GASOLINE MARKETING INDUSTRY (continued)

Item Number in Docket A-84-07	Date of Correspondence	Commenter and Affiliation
I-H-71	10-15-84	Mr. L. Carl Adams Executive Vice President Florida Petroleum Marketers Association 209 Office Plaza Tallahassee, FL 32301
I-H-72	10-9-84	Mr. Barry W. Muller State of Rhode Island and Providence Plantation Department of Environmental Management 75 Davis St. - 204 Cannon Bldg. Providence, RI 02908
I-H-73	9-21-84	Ms. Barbara Morin State of Rhode Island and Providence Plantation Department of Environmental Management Providence, RI 02908 (Extension requested)
I-H-74	10-4-84	Mr. W.W. Hazlett Hazlett Engineering Co. 1089 Indian Village Road Pebble Beach, CA 93953
I-H-75	10-17-84	Mr. Samuel Chico, Jr. Chico Dairy Company 331 Beechurst Avenue Morgantown, WV 26505
I-H-76	10-17-84	Mr. Mike Sparkman, Vice President Modern Oil Co., Inc. P.O. Box 218 Shawnee, OK 74801
I-H-77	10-18-84	Mr. Gerald J. Helfenkein President - Treasurer Marane Oil 501 Park Avenue Worchester, MA 01610
I-H-78	10-17-84	Mr. R.G. Elmore Executive Vice President J&L Oil Company, Inc. Box 214A Mundelein, IL 60060

Table 1-1. LIST OF COMMENTERS ON EVALUATION OF REGULATORY STRATEGIES FOR THE GASOLINE MARKETING INDUSTRY (continued)

Item Number in Docket A-84-07	Date of Correspondence	Commenter and Affiliation
I-H-79	10-22-84	Mr. Erv Lackey, Chairman Lackey, Distributing, Inc. Chevron Petroleum Jobbers 5275 East 48th Avenue Denver, CO 80216
I-H-80	10-22-84	Mr. Tom Slamans, Distributor P.O. Box 603 Okmulgee, OK 74447
I-H-81	10-23-84	Mr. Kenneth A. Baker Vice President J.D. Streett & Company, Inc. 144 Weldon Parkway Maryland Heights, MO 63043
I-H-82	10-23-84	Mr. Milton Feldstein Air Pollution Control Officer Bay Area Air Quality Management District 939 Ellis Street San Francisco, CA 94109
I-H-83	10-19-84	Mr. Phillip L. Youngblood Director, Air Programs Conoco, Inc. P.O. Box 2197 Houston, TX 77252
I-H-84	10-24-84	Mr. Dave Fellers, CAE Executive Vice President Texas Oil Marketers Assoc. 701 W. 15th Street Austin, TX 78701
I-H-85	10-22-84	Mr. Charles V. Stuckey, CAE Executive Vice President Oklahoma Oil Marketers Assoc. 5115 N. Western Oklahoma City, OK 73118
I-H-86	10-29-84	Mr. J.J. van der Veken, Manager Gas Stations Operations & Maintenance Northville Gasoline Corp. P.O. Box 937 Melville, NY 11747

Table 1-1. LIST OF COMMENTERS ON EVALUATION OF REGULATORY STRATEGIES FOR THE GASOLINE MARKETING INDUSTRY (continued)

Item Number in Docket A-84-07	Date of Correspondence	Commenter and Affiliation
I-H-87	Undated	Mr. John S. Hough, President Hough Fuel 340 Fourth Street Trenton, NJ 08638
I-H-88	11-1-84	Mr. Carl C. Greer, President Martin Oil Marketing Corp., Ltd. P.O. Box 298 Blue Island, IL 60406
I-H-89	11-2-84	Mr. Thomas F. Wentworth General Manager Solar Oil Company, Inc. P.O. Box 127 Hope, NJ 07844
I-H-90	10-30-84	Mr. Barnard R. McEntire County of San Diego Air Pollution Control District 9150 Chesapeake Drive San Diego, CA 92123-1095
I-H-91	11-1-84	Mr. A.G. Smith Shell Oil Company P.O. Box 4320 Houston, TX 77210
I-H-92	11-5-84	Mr. Bill Stewart Executive Director Texas Air Control Board 6330 Highway, 290 East Austin, TX 78723
I-H-93	11-5-84	Mr. Frank T. Ryan, Vice President Rubber Manufacturers Assoc. 1400 K. Street, N.W. Washington, D.C. 20005
I-H-94	11-6-84	Mr. John W. Graves Director of Environmental Safety and Health Affairs Pennzoil Company P.O. Box 2967 Houston, TX 77252-2967

Table 1-1. LIST OF COMMENTERS ON EVALUATION OF REGULATORY STRATEGIES FOR THE GASOLINE MARKETING INDUSTRY (continued)

Item Number in Docket A-84-07	Date of Correspondence	Commenter and Affiliation
I-H-95	11-5-84	Mr. George P. Ferreri, Director Air Management Administration Maryland Dept. of Health & Mental Hygiene 201 West Preston Street Baltimore, MD 21201
I-H-96	Undated	Mr. Robert L. Claibourne Claibourne Oil Company P.O. Box 787 Miami, OK 74354
I-H-97	Undated	Mr. Ray Reed Bowling Oil Co., Inc. P.O. Box 1282 Seminole, OK 74868
I-H-98	11-7-84	Mr. W.T. Danker Manager, Environmental Programs Chevron U.S.A., Inc. P.O. Box 7643 San Francisco, CA 94120-7643
I-H-99	11-5-84	Mr. Paul D. Collier Executive Vice President Amoco Oil Company 200 East Randolph Drive Chicago, IL 60601
I-H-100	11-7-84	Mr. William Shapiro Manager, Regulatory Affairs Volvo - North American Operations Rockleigh, NJ 07647
I-H-101	11-5-84	Mr. R.R. Love, Chief Engineer Emissions and Fuel Economy Certification Chrysler Corporation P.O. Box 1118 Detroit, MI 48288
I-H-102	11-8-84	Ms. Barbara Faulkner Vice President, Policy & Legal Affairs Petroleum Marketers Association 1707 H Street, N.W. Suite 1100 Washington, D.C. 20006

Table 1-1. LIST OF COMMENTERS ON EVALUATION OF REGULATORY STRATEGIES FOR THE GASOLINE MARKETING INDUSTRY (continued)

Item Number in Docket A-84-07	Date of Correspondence	Commenter and Affiliation
I-H-103	11-7-84	Mr. S. William Becker Executive Director STAPPA/ALAPCO 444 North Capitol St., N.W. Washington, D.C. 20001
I-H-104	11-8-84	Mr. Brian Gill, Manager Certification Department American Honda Motor Co., Inc. P.O. Box 50 Gardena, CA 90247
I-H-105	Undated	Mr. Bedford M. Mitchell Vice President Carey Johnson Oil Co., Inc. P.O. Box 286 Lawton, OK 73502
I-H-106	Undated	Mr. R.J. O'Halloran O'Halloran Oil Corp. Perry, OK
I-H-107	11-7-84	Mr. Glenn E. Moore Vice President - Engineering Dover Corp. OPW Division P.O. Box 405003 Cincinnati, OH 45240-5003
I-H-108	11-8-84	Mr. Jeffrey L. Leiter Collier, Shannon, Rill & Scott 1055 Thomas Jefferson Street, N.W. Washington, D.C. 20007 (representing SIGMA)
I-H-109	11-8-84	Mr. J.C. Hildrew, Manager Environmental Affairs Mobil Oil Corporation P.O. Box 1031 Princeton, NJ 08540
I-H-110	11-5-84	Mr. William G. Maxwell Red Rock/Pate Oil Distributing Co. P.O. Box 82336 Oklahoma City, OK 73148
I-H-111	10-31-84	Mr. Detlev E. Hasselmann Hasstech, Inc. 8821 Production Avenue San Diego, CA 92121

Table 1-1. LIST OF COMMENTERS ON EVALUATION OF REGULATORY STRATEGIES FOR THE GASOLINE MARKETING INDUSTRY (continued)

Item Number in Docket A-84-07	Date of Correspondence	Commenter and Affiliation
I-H-112	11-7-84	Mr. S. Perkins, President Perkins Petroleum, Inc. P.O. Box 1078 Guymon, OK 73942
I-H-113	11-6-84	Mr. U.V. Henderson Texaco, Inc. P.O. Box 509 Beacon, NY 12508
I-H-114	11-8-84	Mr. Donald R. Buist, Director Automotive Emissions and Fuel Economy Office Ford Motor Company The American Road Dearborn, MI 48121
I-H-115	11-9-84	Mr. David D. Doniger Natural Resources Defense Council, Inc. 1350 New York Avenue, N.W. Suite 300 Washington, D.C. 20005
I-H-116	11-8-84	Mr. W. Groth, Manager Emissions Regulations & Certifications Volkswagen of America, Inc. 888 W. Big Beaver P.O. Box 3951 Troy, MI 48007-3951
I-H-117	11-8-84	Mr. T.M. Fisher, Director Automotive Emission Control General Motors Corporation General Motors Technical Center Warren, MI 48090
I-H-118	11-13-84	Mr. James D. Boyd Executive Officer California Air Resources Board 1102 Q Street Sacramento, CA 95812
I-H-119	11-8-84	Mr. Jeffrey L. Leiter Collier, Shannon, Rill, & Scott 1055 Thomas Jefferson Street, N.W. Washington, D.C. 20007 (representing National Assoc. of Convenience Stores)

Table 1-1. LIST OF COMMENTERS ON EVALUATION OF REGULATORY STRATEGIES FOR THE GASOLINE MARKETING INDUSTRY (continued)

Item Number in Docket A-84-07	Date of Correspondence	Commenter and Affiliation
I-H-120	11-8-84	Mr. William F. O'Keefe Vice President American Petroleum Institute 1220 L Street, NW Washington, D.C. 20005
I-H-121	Undated	Mr. R.A. Davis, President Denver Oil Company P.O. Box 94597 Oklahoma City, OK 73143
I-H-122	11-14-84	Mr. James K. Hambright, Director Bureau of Air Quality Control Commonwealth of Pennsylvania P.O. Box 2063 Harrisburg, PA 17120
I-H-123	11-5-84	Mr. R. Manning Manning Oil Company P.O. Box 576 Pauls Valley, OK 73075
I-H-124	11-5-84	Mr. Harry H. Hovey, Jr. Director, Division of Air New York State Department of Environmental Conservation 50 Wolf Road Albany, NY 12233-0001
I-H-125	11-8-84	Mr. Raymond J. Campion Coordinator Public Affairs Dept., Environmental Conservation Exxon Company, U.S.A. P.O. Box 2180 Houston, TX 77001
I-H-126	11-19-84	Ms. Jan W. Mares, Asst. Secretary Policy, Safety and Environment Department of Energy Washington, D.C. 20585
I-H-127	11-8-84	Mr. Fred W. Bowditch, Vice President Technical Affairs Motor Vehicle Manufacturers Assoc. 300 New Center Building Detroit, MI 48202

Table 1-1. LIST OF COMMENTERS ON EVALUATION OF REGULATORY STRATEGIES FOR THE GASOLINE MARKETING INDUSTRY
(continued)

Item Number in Docket A-84-07	Date of Correspondence	Commenter and Affiliation
I-H-128	11-16-84	Mr. W.C. Jones, Manager Governmental Regulations American Motors Corporation 14250 Plymouth Road Detroit, MI 48232
I-H-129	10-25-84	Mr. Robert D. Bradt Hirt Combustion Engineers 931 South Maple Avenue Montebello, CA 90640-5488
I-H-130	11-6-84	Mr. Vic Rasheed, Executive Director Service Station Dealers of America 400 North Capitol Street, N.W. Suite 175 Washington, D.C. 20001
I-H-131	11-7-84	Mr. Ron M. Clark President & General Manager Emco Wheaton, Inc. P.O. Box 688 Conneaut, OH 44030-0688
I-H-132	11-7-84	Mr. James W. Healy Cambridge Engineering, Inc. 74 Faulkner Street North Billerica, MA 01862
I-H-133	12-18-84	Mr. Fred W. Bowditch, Vice President, Technical Affairs Motor Vehicle Manufacturers Assoc. 300 New Center Bldg. Detroit, MI 48202
I-H-134	11-6-84	Ms. Cynthia Winklevoss Slippery Rock University Slippery Rock, PA 16057
I-H-135	1-10-85	Mr. T.M. Fisher, Director Automotive Emission Control General Motors Corp. Warren, MI 48090
I-H-136	2-22-85	Mr. T.M. Fisher General Motors Corporation Warren, MI 48090

Table 1-1. LIST OF COMMENTERS ON EVALUATION OF REGULATORY STRATEGIES FOR THE GASOLINE MARKETING INDUSTRY (continued)

Item Number in Docket A-84-07	Date of Correspondence	Commenter and Affiliation
I-H-137	4-25-86	Mr. D.E. Hoag Plymouth Oil Company P.O. Box 27147 Detroit, MI 48227
I-H-138	4-24-86	Mr. J. Edward Surette, Jr. Executive Director Bay State Gasoline Retailers Association 574 Boston Road (Rt. 3A) Billerica, MA 01821
I-D-51	3-25-85	Mr. H.G. Grayson Mobil Oil Corporation 150 East 42nd Street New York, NY 10017
I-D-52	5-16-85	Mr. B.E. Doll, Manager Air Programs Mobil Oil Corporation P.O. Box 1031 Princeton, NJ 08540
I-D-53	6-24-85	Mr. John M. Daniel, Jr. Asst. Executive Director Air Pollution Control Board, Commonwealth of Virginia P.O. Box 10089 Richmond, VA 23240
I-D-54	7-23-85	Mr. Charles J. DiBona, President American Petroleum Institute Washington, D.C. 20005 (signed by four other trade representatives)
I-D-55	7-25-85	Mr. J.C. Hildrew, Manager Environmental Affairs Mobil Oil Corporation Princeton, NJ 08540
I-D-56	8-6-85	Mr. C.L. Terlizzi, Manager National Accounts The B.F. Goodrich Company 500 South Main Street Akron, OH 44318

Table 1-1. LIST OF COMMENTERS ON EVALUATION OF REGULATORY STRATEGIES FOR THE GASOLINE MARKETING INDUSTRY (concluded)

Item Number in Docket A-84-07	Date of Correspondence	Commenter and Affiliation
I-D-57, I-D-68	7-23-85	Mr. Mark Cooper Energy Director Consumer Federation of America 1424 16th Street, N.W. Washington, D.C. 20036
I-D-58	8-23-85	Mr. Robert A. Rogers, Director Automotive Emission Control General Motors Corporation Warren, MI 48090
I-D-59	10-23-85	Mr. Robert A. Rogers, Director Automotive Emission Control General Motors Corporation Warren, MI 48090
I-D-63	10-16-85	Mr. Howard H. Kehrl Vice Chairman General Motors Corporation 3044 West Grand Boulevard Detroit, MI 48202
I-D-64	12-17-85	Mr. J.J. Wise, Manager Paulsboro Research Lab Mobil R&D Corporation Paulsboro, NJ 08066
I-D-65	4-19-85	Mr. Robert E. Hughey Commissioner Dept. of Environmental Protection State of New Jersey Trenton, NJ 08625
I-D-67	7-19-85	Mr. Phillip R. Chisolm Executive Vice President Petroleum Marketers Association of America 1120 Vermont Avenue Washington, D.C. 20005
I-D-70	9-30-85	Mr. James E. Benton Executive Director New Jersey Petroleum Council 170 West State Street Trenton, NJ 08608

All references used in this document are contained in EPA's Gasoline Marketing Docket (No. A-84-07). Each document in this docket is assigned a docket item number. These same docket item numbers are used as reference numbers in this document. The docket is available for public inspection and coping at EPA's Central Docket Section, West Tower Lobby, Gallery 1, Waterside Mall, 401 M Street S.W., Washington, D.C. 20460 (phone number 202-382-7549). A reasonable fee may be charged for copying.

1.1 REFERENCES

I-A-55 Evaluation of Air Pollution Regulatory Strategies for Gasoline Marketing Industry, U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, and Office of Mobile Sources, EPA-450/3-84-012a (Executive Summary - EPA-450/3-84-012b), July 1984, [NTIS # PB 84 231075 and PB 84 231083, respectively].

1*. Draft Regulatory Impact Analysis, Proposed Refueling Emission Regulations for Gasoline-Fueled Vehicles -- Volume I - Analysis of Gasoline Marketing Regulatory Strategies (EPA-450/3-87-001a), Volume II - Additional Analysis of Onboard Controls (EPA-450/3-87-001b), U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, and Office of Mobile Sources, July 1987.

*Docket number not available. These documents will be published at the same time as this report and will be assigned docket numbers and placed in the docket at that time.

2.0 DISCUSSION AND COMMENTS ON ONBOARD CONTROLS

2.1 ONBOARD CONTROL TECHNOLOGY*

The technological aspects of onboard control of refueling emissions were discussed in an EPA technical report that was included as Appendix C of the July 1984 EPA analysis document (I-A-55). Since that report was issued, EPA has received numerous public comments on all aspects of onboard controls and has re-evaluated many of its concepts and estimates. The results of the Agency's re-evaluation is presented in this chapter.

The first part of this chapter describes a general onboard control system. Then several design considerations and recent onboard development work are discussed. This is followed by the description of the specific onboard system that EPA is considering in this analysis. Costs and other aspects of this system are thoroughly discussed. Finally, Agency responses to significant comments on onboard issues are presented.

2.1.1 General Description of an Onboard System

In many ways a refueling vapor control system is similar to the evaporative emission control systems now in use on most automobiles. Vapors that are displaced from the fuel tank during a refueling event are adsorbed onto a bed of activated carbon, where they are stored. During vehicle operation, manifold vacuum is used to pull ambient air over the carbon bed, desorbing the stored hydrocarbons from the canister. The hydrocarbon-rich purge gas is then routed to the engine and the hydrocarbons are burned in the engine during combustion.

In some respects, however, the onboard refueling vapor control system differs from an evaporative control system. The biggest physical difference between the systems is caused by the need to prevent vapors from escaping via the fillneck during a refueling event. This need forces the introduction of some type of sealing mechanism into the fuel tank fillneck. Although there are a variety of fillneck seals capable of performing the necessary task, the one discussed in the July 1984 analysis is a simple mechanical seal (such as that shown in Figure 2-1)

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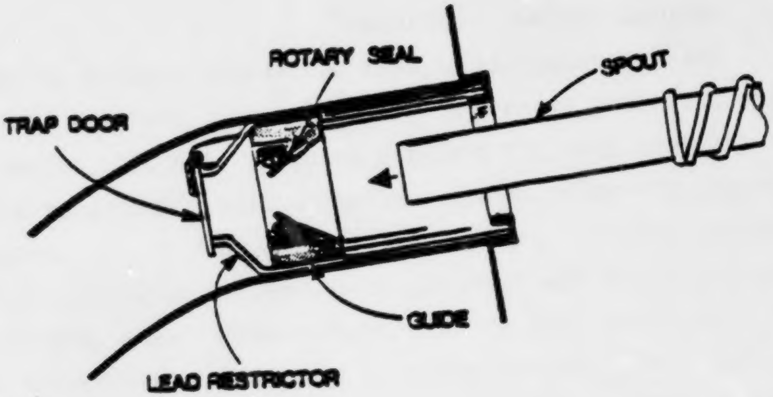
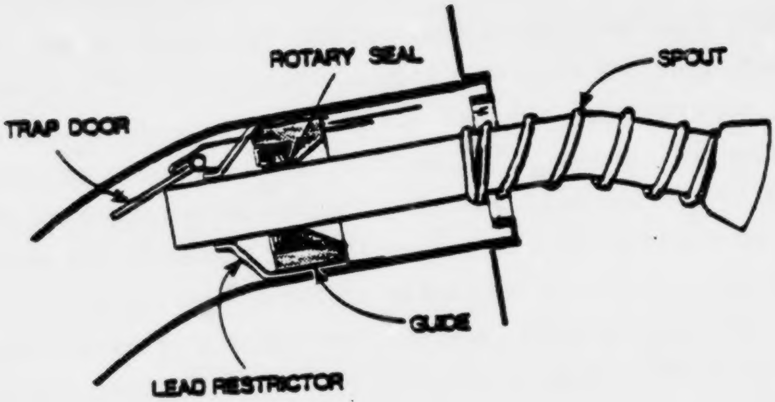
*1984 Federal Register topic.


ROTARY SEAL
SPOUT
TRAP DOOR
GUIDE
LEAD RESTRICTOR

a. Spout entering fillneck


ROTARY SEAL
SPOUT
TRAP DOOR
GUIDE
LEAD RESTRICTOR

b. Spout sealed by rotary seal

Figure 2-1. Onboard System Mechanical Seal

located near the top of the fillneck. When the gasoline dispensing nozzle is inserted into the fillneck, an interface is formed between the seal and the fillneck, preventing displaced vapors from escaping into the atmosphere. Instead of leaving the fuel tank via the fillneck, the displaced vapors are routed to the onboard canister where adsorption occurs.

Another difference between the evaporative and refueling vapor control systems is the frequency and magnitude of canister loadings. Evaporative emissions are produced each time a vehicle is operated, as well as in response to diurnal temperature cycles. This could mean several evaporative loads per day, even if the vehicle were operated only a few miles at a time. Refueling emissions, on the other hand, are generally produced less frequently and can be much larger in magnitude on a per-event basis. A significant amount of mileage is generally accumulated between refueling events. Because of the potential for a large quantity of refueling emissions at any one time, more hydrocarbon storage capacity would be needed for refueling emissions than is needed for evaporative emissions.

This difference in the timing and magnitude of emission loads results in the need for purge schedules different from those used in current evaporative systems. The need to accommodate high vapor flow rates and large hydrocarbon loads has several implications for the requirements of the onboard system. First, a larger hydrocarbon storage canister is needed to collect and store the refueling emissions. Depending on cost and vehicle design considerations, a manufacturer could choose to use an integrated, partially integrated, or separate approach to the control of evaporative and refueling emissions. The "separate" approach would involve two (or more) canister systems, each of which would be loaded with evaporative or refueling emissions. A "partially integrated" system would route refueling and some evaporative emissions to one canister, but only evaporative emissions to a separate canister. An "integrated" system would use a single canister (or canisters) into which both evaporative and refueling emissions would be loaded. By using an integrated or even a partially integrated approach, a manufacturer could limit the total amount of activated carbon needed for both refueling and evaporative emission control, and reduce the overall vapor handling system requirement. However, in either case, additional storage capacity would be necessary.

In addition to larger canisters, larger fuel tank vent lines would also be needed. Refueling vapors typically leave the fuel tank at rates of eight gallons per minute or more. In order to accommodate these high vapor flow rates without an excessive rise in fuel tank backpressure, a vapor line with an inside diameter of about 5/8 inch would probably have to be used. Since current evaporative vent lines are smaller than this, a larger vent line would have to be added.

The need to provide a large, unrestricted vent line between the fuel tank and canister during refueling could also lead to a potential safety hazard that is not a serious problem for evaporative emission control systems. Due to the large vent line needed between the fuel tank(s) and canister(s), there is a potential for a significant amount of fuel spillage in the event of an accident involving a vehicle rollover. Current evaporative emission control systems utilize a limiting orifice (40 to 60 thousandths of an inch in diameter) in the vent line to limit the flow of fuel from the tank in rollover situations. To prevent major fuel spills following vehicle rollover, a mechanism would have to be included as part of an onboard system which would provide vent line closure in rollover situations. This mechanism could provide vent line closure at all times other than refuelings, or could be designed to close in response to rollover. Regardless of the specific component design, some type of rollover protection would have to be included in onboard control systems. This subject is discussed further in Section 2.1.5.

Although there are other differences between evaporative and refueling/evaporative emission control systems, the major distinctions have been highlighted above. Details of the functioning of onboard systems will be provided below. The next section of this chapter examines recent developments in onboard control technology. Specifically, these developments involve the method of sealing the fillneck during refueling.

2.1.2 Recent Developments in Onboard Control

In the onboard control system described in Appendix C of the July 1984 EPA analysis, the fillneck is sealed during refueling by means of a mechanical elastomeric device (see Figure 2-1). This type of seal was shown to control refueling emissions with a theoretical efficiency of greater than 98 percent in a demonstration program done by the American Petroleum Institute (API) in 1978 (I-F-17). Although the demonstration program did prove the theoretical efficiency of this type of seal to be adequate, the comments on the information in Appendix C suggested a number of potential problems with mechanically sealed systems.

A number of commenters voiced their doubts about the durability of mechanical seals. Although the API demonstration vehicles were driven up to 65,000 miles, none was driven the light-duty vehicle (LDV) average lifetime of 100,000 miles, and a number of commenters questioned the ability of the seal to retain its integrity over the life of the vehicle in a wide range of environmental conditions.

Many commenters also stated that a pressure relief device would be needed if the mechanical type fillpipe seal were used. This would be needed to prevent damage to the fuel tank and other system components if the automatic nozzle shutoff mechanism failed or if the vapor line between the fuel tank and an onboard refueling canister became blocked. In these situations, the fuel tank could come under excessive pressure as more fuel was dispensed into the tank. Also, if the fuel tank were slightly overpressured as described above, a pressure relief device would also help to reduce fuel spit-back which could occur when the nozzle was removed from the fillpipe. Although an adequate pressure relief device could be designed without an unreasonable amount of effort, the commenters argued that such a device would add an additional level of cost and complexity to the system.

A number of commenters felt that adding a mechanical seal to the fillneck would lead to tampering or abuse by the consumer, since the nozzle would have to be inserted into the fillneck with a certain degree of care. Although this would not require an unacceptable level of additional effort, they felt it would involve a deviation from the traditional refueling experience which could ultimately lead to fillpipe tampering. Any such tampering would likely lead to a decrease in the effectiveness of the control strategy.

These purported problems (even if true) would not prohibit the use of a mechanical seal, but they do highlight the need for improvements in these devices. A possible alternative to the mechanical seal is a "liquid seal" device. These liquid seals employ modified fillneck designs which route the incoming gasoline in such a way that a column of gasoline prevents the fuel tank vapors from escaping to the atmosphere during refueling. Liquid seals have been considered as part of onboard systems during most of the history of the study of the control of refueling emissions. At least as early as 1979, EPA did work to test the control efficiency of an onboard system equipped with a liquid fillneck seal (I-B-18). In the 1979 test program, a "submerged fill" liquid seal system was tested and showed a control efficiency of 99 percent. More recently, EPA performed a series of tests at the Motor Vehicle Emissions Laboratory (MVEL) which examined the control efficiencies of a number of liquid seals. The liquid seal work done by EPA at the MVEL is fully described in a technical report available in the public docket (I-A-109). Only the highlights of the study will be repeated here.

Three liquid seal systems were evaluated in the EPA study: the "in-tube trap," the submerged fill, and the "J-tube." The in-tube trap (shown in Figure 2-2) is similar in concept to the standard sink drainpipe. The submerged fill system (Figure 2-3) employs a fillneck that extends into the fuel tank and introduces gasoline near the bottom of the tank. When the gasoline level rises in the tank during a fueling event, the fillneck opening is submerged in the gasoline and vapors are trapped in the tank above the liquid level. The J-tube (Figure 2-4) is a simplified form of the in-tube trap. The fuel being dispensed into the fillneck is forced to pass through the "U"-shaped portion of the fillneck. The liquid trap is formed as the gasoline passes from the lowest point in the "U" to the opening of the fillneck in the tank. The submerged fill and J-tube systems were identified as practical alternatives to the mechanical seal systems. The J-tube was shown to control refueling emissions with an efficiency of at least 97 percent. The J-tube evaluation was conducted on a bench prototype, which was later installed in a vehicle. It is clear that higher efficiencies are achievable with more fully developed systems (I-H-158). The advantages that these sealing approaches have over the mechanical type seals are described below.

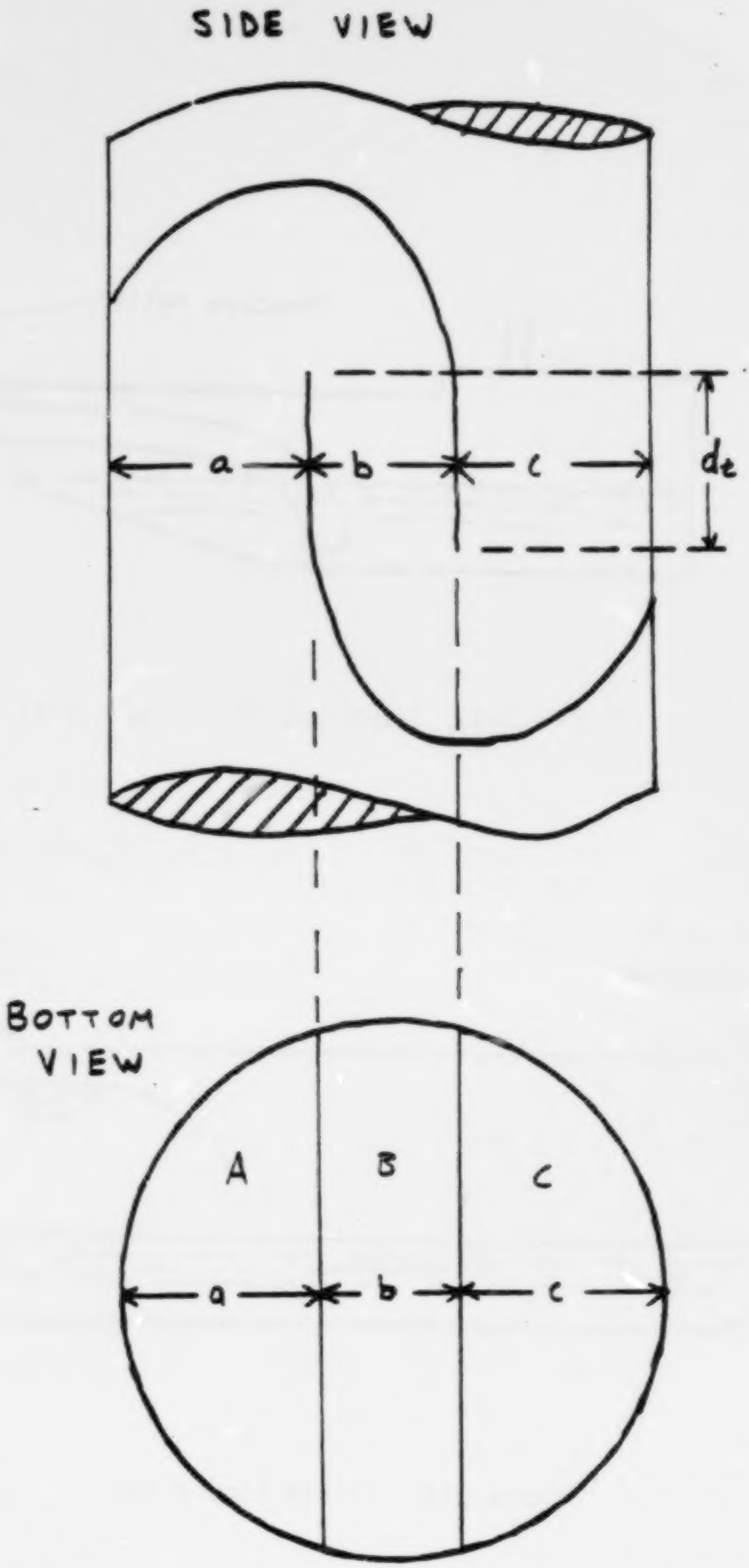

SIDE VIEW
a
b
c
d_t
BOTTOM VIEW
A
B
C
a
b
c

Figure 2-2. In-Tube Trap Liquid Seal

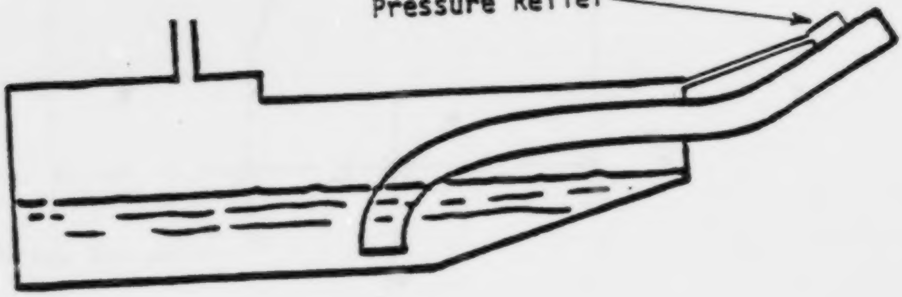

Pressure Relief

Figure 2-3. Submerged Fill Liquid Seal

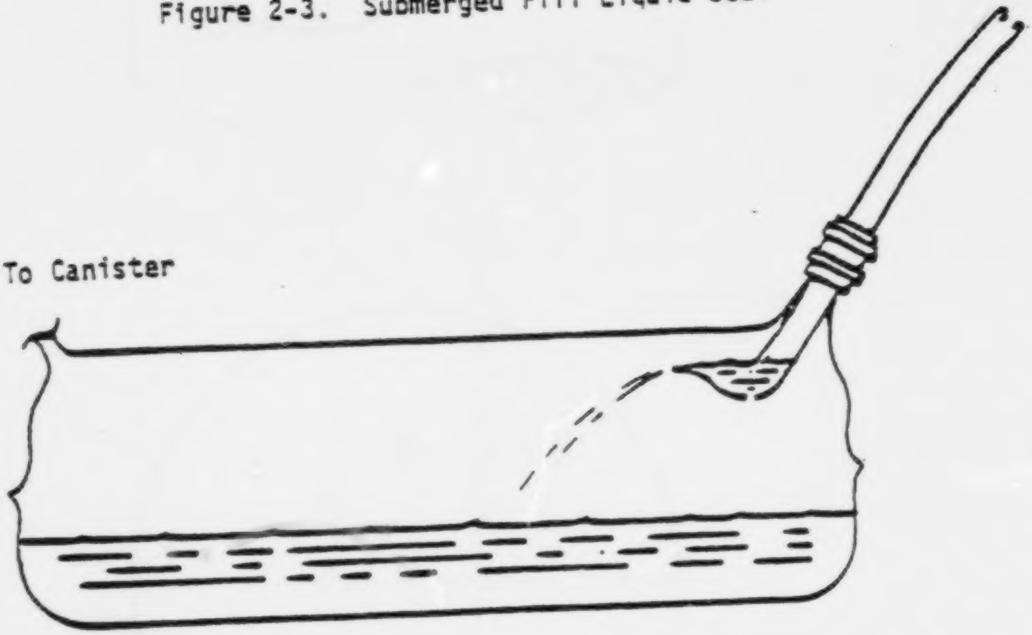

To Canister

Figure 2-4. J-Tube Liquid Seal

Some commenters cited the purported lack of durability as a possible deficiency of the mechanical seal. Clearly, a liquid seal system would eliminate any questions concerning durability. A new liquid seal is formed with each refueling and there are no mechanical parts to wear with time. The same line of reasoning can be used to respond to the questions about the susceptibility of the mechanical seal to environmental extremes. Extremely hot or cold weather would have no effect on the performance of the liquid seals. The possibility of fillneck tampering would be eliminated by using a liquid seal, since the outward appearance of a submerged fill or J-tube fillneck would be no different from the appearance of the current fillneck. Therefore, the addition of the liquid seal would not increase the incentive to tamper.

The other potential drawback to the mechanical seal is its need for a pressure relief device. The liquid seal systems are an improvement over the mechanical seal in this area as well. Both the J-tube and the submerged fill systems avoid the problem of fuel tank over-pressure during a refueling event. Any tank over-pressure that occurred while fuel was being dispensed into the tank would cause fuel to rise in the fillneck and automatic nozzle shutoff to occur. Any pressure buildup is automatically released through the fillneck. Similarly, failure of the nozzle automatic shutoff mechanism would have no additional safety implications with liquid seal systems, since failure would result in a fuel spit-back and subsequent manual shutoff as now occurs.

Both of these systems avoid over-pressure during refueling, but only the J-tube system can function safely without a pressure relief mechanism of any kind. The submerged fill system is, however, potentially susceptible to a potential safety problem of another kind and may require a pressure relief device. If the lines between the fuel tank and the carbon canister were blocked between fueling events, pressure could build in the tank during normal operation of the vehicle. If the vehicle's gas cap was removed while the tank was still relatively full, gasoline could be forced out of the fillnect (which would contain a standing column of gasoline) and possible onto the nozzle operator. Although this situation might arise only on rare occasions, a pressure relief mechanism may be required for some submerged fill systems to prevent the possibility of fuel spit-back. It should be noted that mechanisms are available that could perform the functions required of the pressure relief device. The adaptation of such mechanisms to this application should be straightforward and inexpensive. This problem can be easily avoided in the J-tube system by allowing the fillneck to drain after the completion of a refueling event. This can be accomplished by drilling a small hole at the base of the liquid seal to allow a slow drain of fuel into the tank following the refueling.

The technical report on the testing of the fillneck seals discusses both the positive and negative aspects of each approach, and the discussion will not be repeated here. The report concludes that both the submerged fill and J-tube systems would be usable, and both would eliminate problems related to durability and tampering. The J-tube system does have one advantage over the submerged fill system in that it does not require a pressure relief device. This tends to make the J-tube approach more attractive than the submerged fill system for both cost and safety reasons. For this reason, the primary onboard control system considered by EPA in this analysis is equipped with a J-tube fillneck seal. However, it should be noted that both the mechanical seal and submerged fill approaches are also technologically feasible and may be preferable in some applications.

Even though the liquid seal approaches may have some initial advantages over the mechanical seal designs which have been demonstrated thus far, this does not imply that mechanical seals cannot or should not be used. Design and incorporation of a pressure relief device into the system is a relatively straightforward engineering task. While tampering could be viewed as a potential problem, EPA would expect that mechanical systems used by manufacturers would incorporate tamper-resistant designs. Also, it is worth noting that much of the incentive for fillneck tampering in the past was related to the consumers' desire to save money through misfueling. With the recent decline in the leaded to unleaded fuel differential, this incentive has diminished. Finally, with regard to the durability of mechanical seals, it should be noted that the vehicles evaluated by API showed no deterioration in the effectiveness of the mechanical seal during the test period. The seals retained their effectiveness over a wide range of environmental conditions and with the use of alcohol blends. If needed, the option for using improved seal materials clearly exists. The rotary grease seal used in the API demonstration project was off-the-shelf hardware which could be improved specifically for this application if necessary. Thus, EPA believes that either liquid seals or mechanical seals could be used as part of onboard systems.

The development of a liquid seal alternative addresses many of the key comments raised with regard to onboard control technology, and to some degree changes the onboard system from that originally discussed in the July 1984 analysis. In addition, the comments have raised other issues which led to further revisions of the analysis of onboard systems. Given these changes, the basic systems discussed in this document have some substantial differences from the system discussed in the 1984 analysis. As an introduction to the analysis of comments, the onboard systems as envisioned by EPA are described in detail. The description of the systems should make the analysis easier to follow and will provide an indirect response to many of the comments.

2.1.3 Description of the Onboard Systems Evaluated by EPA

The onboard systems are described here in terms of both function and form. The reader is led through a typical refueling event and the on-board hardware is described as each component performs its function. The description of the refueling event is presented so that the reader can get a feel for both the technical workings of the system and its interaction with the operator of the gasoline nozzle.

The EPA envisions two types of onboard systems, one for fuel-injected vehicles and one for carbureted vehicles. The difference in the systems is brought about by the need for control of evaporative hot soak emissions from the carburetor bowl(s) of carbureted vehicles. Because of the current trend toward fuel injection and the associated projections for an 88 percent fuel-injected light-duty fleet by 1990 (I-A-70), the onboard system for fuel-injected vehicles is the primary system described. The differences in the carbureted-type system are also briefly noted. Because the system for fuel-injected vehicles employs the use of a single canister for both refueling and evaporative emission control, it is referred to as a "fully integrated" system. The system for carbureted vehicles uses separate canisters to control emissions from the fuel tank and carburetor bowl(s), and is therefore referred to as a "partially integrated" system. Figure 2-5 shows a typical fully integrated, onboard refueling and evaporative control system.

The description of the system operation begins as the vehicle operator parks the vehicle at the service station and the gas cap is removed. The opening of the gas cap cover and removal of the gas cap relays information to the electronic control unit (ECU), signaling the start of the refueling event. In the system envisioned by EPA, the switch is triggered by the removal of the gas cap as shown in Figure 2-6, but there are a number of other possible switch positions. Many of these are described in a report written by Mueller Associates for EPA in 1985. This report, entitled, "Costs of Onboard Vapor Recovery Hardware," has been included as part of the public docket (I-A-77). Therefore, these other possible locations will not be described here.

The removal of the gas cap throws a switch to indicate that a refueling event is about to take place by sending a signal to a solenoid valve located in the vapor line between the fuel tank and the carbon canister. Figure 2-7 is a diagram of one such valve. A complete description of the valve can be found in the Mueller Report referenced above. The valve moves to the open position, allowing vapor to pass out of the fuel tank at the high rates necessary during a refueling event.

As was discussed earlier (Section 2.1.1), a relatively large (approximately 1/2 to 5/8-inch inner diameter) vapor vent line would be needed between the fuel tank and canister to accommodate the high vapor flow rates (>8 gpm) associated with refueling. An onboard control system must include some provision to allow the necessary flow during refueling and to prevent excessive fuel spillage should the vehicle roll over. The solenoid valve discussed in the previous paragraphs is one possible method of satisfying both of these requirements; the valve is open during refueling events and closed during other modes of operation. Another approach that could be used to solve this problem is discussed in a recently published API report (I-H-158). In their work for API, Mobil Research and Development used a valve that was mechanically opened by the act of nozzle insertion to permit vapor flow during refuelings. Although this and other approaches are feasible, the

Figure 2-5. INTEGRATED EVAPORATIVE/REFUELING SYSTEM

TANK MOUNTED VALVES
REAR MOUNTED CANISTER
J-TUBE SEAL

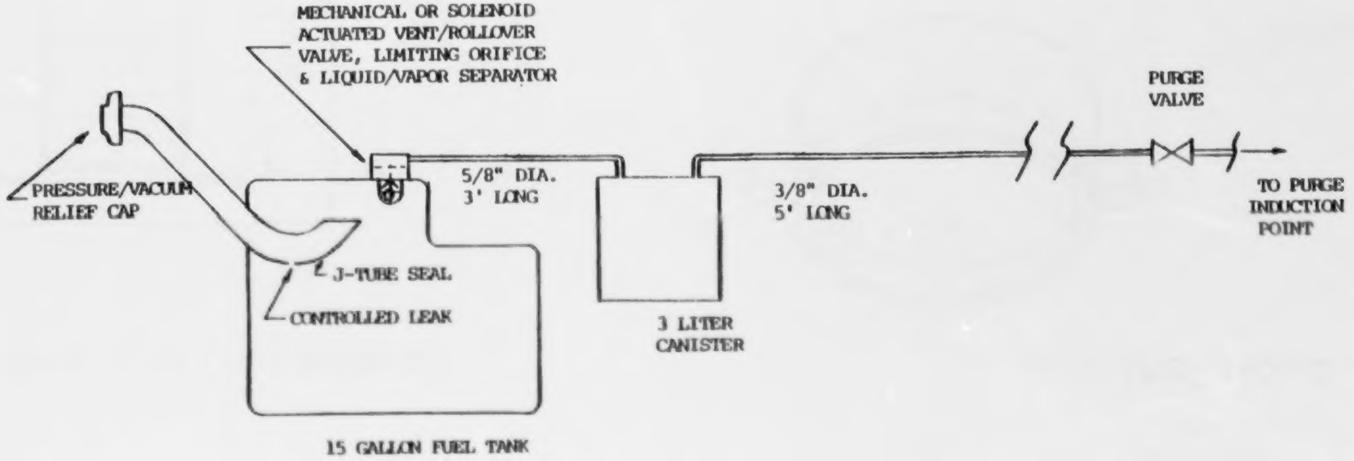

MECHANICAL OR SOLENOID ACTUATED VENT/ROLLOVER VALVE, LIMITING ORIFICE & LIQUID/VAPOR SEPARATOR
PURGE VALVE
PRESSURE/VACUUM RELIEF CAP
5/8" DIA. 3' LONG
3/8" DIA. 5' LONG
TO PURGE INDUCTION POINT
J-TUBE SEAL
CONTROLLED LEAK
3 LITER CANISTER
15 GALLON FUEL TANK

Figure 2-6. Vent Valve Activation Switch

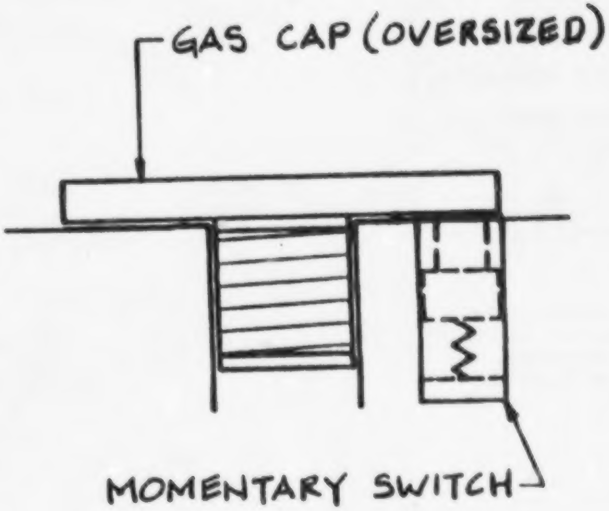
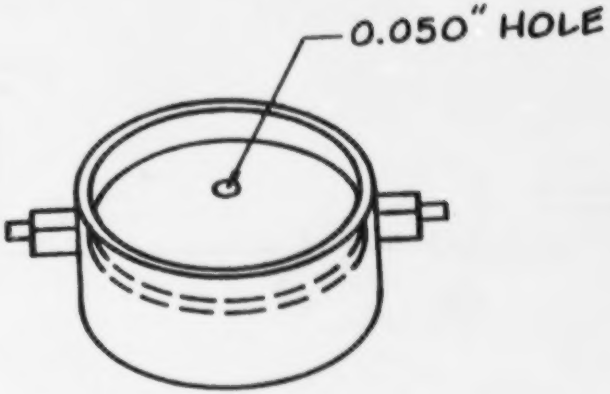

GAS CAP (OVERSIZED)
MOMENTARY SWITCH

Figure 2-7. Vapor Vent Valve



NO SCALE

MUELLER ASSOCIATES, INC.
1401 S. EDGEWOOD STREET
BALTIMORE, MARYLAND 21227
JANUARY 31, 1986

example presented here presumes the use of the solenoid type system.

At about the same time that the solenoid valve opens the vapor line, the operator inserts the fuel nozzle into the fillneck. Since this system uses a J-tube liquid seal, the nozzle operator would notice no difference between the fillneck of the controlled vehicle and the fillneck on an uncontrolled vehicle of the same make. As gasoline flows down the fillneck and into the tank, a liquid trap is formed in the fillneck almost immediately. As gasoline fills the tank, vapors are displaced from the tank. Since the liquid trap has formed in the fillneck, vapors cannot leave through the fillneck and are forced to pass out of the tank via the refueling vent line which connects the fuel tank to the carbon canister. After vapors pass out of the fuel tank they pass through a liquid/vapor separator. The liquid/vapor separator removes gasoline droplets from the vapor stream and returns the liquid fuel to the tank. The separation of this liquid gasoline from the vapor flow helps to reduce the hydrocarbon load reaching the canister and prevents liquid gasoline droplets from poisoning the canister.

The refueling vapors then pass through the vapor line (5/8-inch diameter) and enter the carbon canister where the hydrocarbons in the vapor stream are adsorbed onto the activated carbon. This canister may be in the front or rear of the vehicle.

Inside the fuel tank, a float valve or some similar device is connected to the vapor inlet orifice (see Figure 2-8). As the gasoline level rises to the top of the tank, the float valve seats itself in a a housing at the vapor orifice. As the float blocks the vapor orifice, the pressure rises in the tank and a column of gasoline rises in the fillneck. When the column of gasoline reaches the tip of the gasoline nozzle, automatic shutoff is triggered and the refueling event is completed. The float housing and float are designed to provide a soft but effective close, so that the pressure in the tank does not rise too high too quickly. This feature is included to help eliminate gasoline spillage at the end of a fueling event.

At the completion of the refueling, when automatic shutoff has been triggered, the operator removes the nozzle from the fillneck and

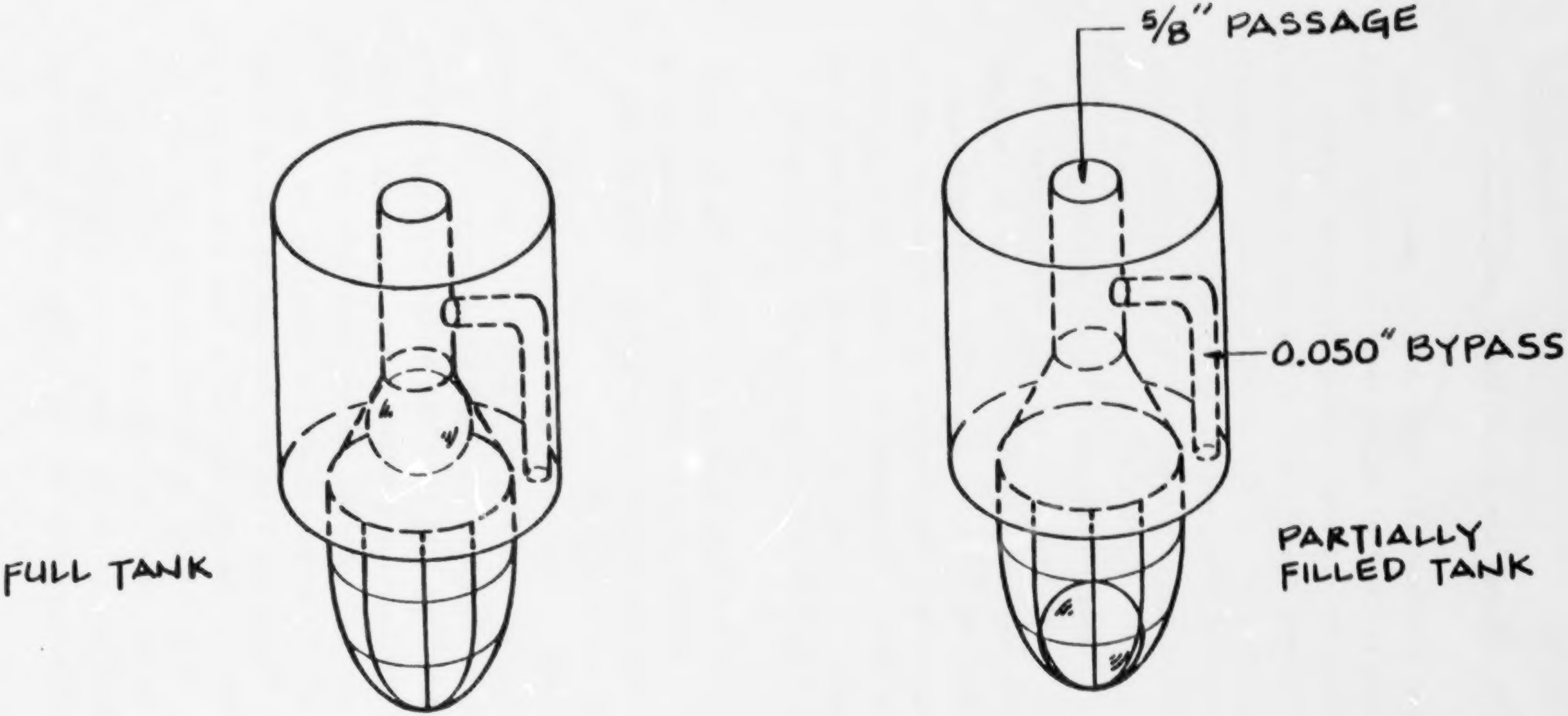

5/8" PASSAGE
0.050" BYPASS
FULL TANK
PARTIALLY FILLED TANK

Figure 2-8. Possible Fill Limiter Design

NO SCALE

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JANUARY 31, 1985

replaces the gas cap. As the gas cap is replaced, the solenoid that opened the vent closure is reversed, and the vent line is closed. Using a mechanical vent closure valve such as that developed by Mobil, the vapor line would close when the nozzle was removed.

The ability of this system to open and close the refueling vapor vent line provides the fuel tank rollover protection required by FMVSS 301. The refueling vapor vent line would remain sealed as long as the solenoid activating the vent closure valve was not activated. Since actuation of the solenoid would require removal of the fuel cap, this approach should provide reasonable certainty of vent closure even in vehicle accidents. Using the mechanical vent closure valve, the system would remain sealed during vehicle operation unless a serious collision destroyed the fillpipe area of the vehicle. In this case, fuel could spill directly from the fillpipe, as could occur on today's vehicles.

Also, when the refueling vent line is closed, the system could be designed to provide a limiting orifice through which evaporative emissions are metered during normal operation of the vehicle. Alternatively, the current limiting orifice system could be retained, with the evaporative emission vapor line for this purpose being "teed" into the refueling vapor line at a point beyond the vent closure valve. While it is not absolutely clear that a limiting orifice is necessary, it has been argued that the use of this orifice is desirable for several reasons such as lower diurnal and running losses and improved vehicle driveability.

After the vehicle has been started and warmed up, the onboard system draws on manifold vacuum to pull air through the onboard canister and purge it of the hydrocarbon load. The integrated system handles evaporative emissions in essentially the same way today's evaporative control systems do. The one change for the integrated system is that the evaporative (diurnal, hot soak, and running loss) emissions would be loaded into a refueling/evaporative canister along with refueling emissions.

As discussed earlier, there are three basic system designs that could be used to control refueling and evaporative emissions. The first is a fully integrated system (described above), in which all evaporative emissions would be loaded into a canister (or canisters) that is also used for refueling vapor control. The second can be called a partially integrated system. A partially integrated system would route all emissions from the fuel tank (both evaporative and refueling) to one canister. Any carburetor bowl (hot soak) emissions would be loaded into a separate canister. This type of system would be used only on carbureted vehicles. Based on the projection that 88 percent of the new car fleet will use fuel injection by 1990, EPA assumed that 12 percent of the fleet will employ this kind of system (I-A-70). The third system is a fully separate system. This type of system would use separate canisters for refueling, evaporative fuel tank, and carburetor emissions.* Because of the necessary complexity of the purge system for such a separate system, EPA does not believe that many of these systems would be used (one possible exception is heavy-duty gasoline vehicles). Therefore, separate systems were not included in this analysis.

The discussion above provides a brief synopsis of the onboard control system envisioned by EPA. The system originally considered by EPA is described in Appendix C of the July 1984 analysis. With a clear image of both the original and modified systems in mind, the comments on technological aspects of onboard control can be analyzed.

2.1.4 Summary and Analysis of Comments

The onboard control system described in Appendix C of the 1984 analysis was based on the mechanical seal approach. Several of the comments received described potential problems with the system described in Appendix C. Some of the comments also contained suggestions for the improvement of the system. As discussed above, after analyzing the comments, EPA has developed revised versions of the basic onboard control systems, which could avoid many of the purported problems raised in the comments. In Chapter 2.0 of this report, the comments on the onboard control system are summarized and the EPA responses to the comments are given. First, the comments on specific hardware items are examined (Section 2.1.4), followed by discussion of more general topics related to onboard controls. For the most part, only the comments opposing various aspects of onboard controls are discussed.

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*A separate system for fuel-injected vehicles would use separate canisters for refueling and evaporative fuel tank loads.

a. Fillneck Seals

Comment: As discussed above, a number of commenters expressed the belief that the mechanical fillneck seal would not be durable enough to last the full life of an LDV or LDT (I-H-2, I-H-11, I-H-99, I-H-100, I-H-101, I-H-116, I-H-120, I-H-127). This conclusion was based on the fact that no vehicle had been operated with onboard controls past 65,000 miles. It was also based on concerns that the seals had not been exposed to the variety of environmental extremes that might be encountered in use. One commenter raised the question of whether an onboard system with a mechanical seal would comply with existing regulations concerning fillneck access. Several others felt that onboard control systems would be subject to tampering (see Section 2.2.5).

Response: In the onboard control system described above, a liquid seal is used to prevent vapors from leaving the fuel tank via the fillneck. As was discussed previously, liquid seal designs such as this avoid many of the potential problems associated with mechanical seals. All problems of durability are eliminated because a new seal is formed with each refueling. The comments on the ability of the seal to function in environmental extremes are also addressed by the use of the liquid seal, since extremely cold or hot weather would have no effect on the functioning of the liquid traps.

The liquid type seals also avoid concerns about tampering, because the modifications to provide the liquid seal would be out of the nozzle operator's sight. From the nozzle operator's perspective, the controlled refueling event would appear identical to the current uncontrolled event.

If a mechanical seal were used, the possibilities of both tampering and durability would have to be considered in seal design. Based on the work done by ARCO, where mechanical seals were tested under adverse weather conditions, it appears that a nozzle seal could be designed to retain its integrity for the full life of the vehicle (I-F-17). The EPA also encourages the development of tamper-resistant designs that would be sturdy enough to discourage most efforts at tampering. However, as mentioned previously tampering is not expected to be a significant problem in future years as the economic incentive to tamper decreases. Finally, the question of fillneck accessibility does not seem to be a major issue. The modifications needed to provide a seal (mechanical or liquid) should not impact current California fillpipe access standards. Onboard equipped vehicles using mechanical seals or liquid seals could still use vapor recovery nozzles.

b. Carbon Canister

Comment: A number of commenters questioned the adequacy of the hydrocarbon storage capacities of the canisters for which costs were given in the July 1984 EPA analysis. Some claimed that the working capacity of the carbon was overestimated, and some felt that the refueling emission load used to size the canister (4.54 g/gal) was underestimated. Later comments stated that the average fuel tank sizes used by EPA for sizing the canisters were too small (13 gal, LDV/18 gal, LDT). Some commenters noted that the large onboard canister might create an unacceptable level of backpressure in the fuel tank during refueling (I-H-90, I-H-118, I-H-127). Also, a number of commenters expressed concern about the durability of carbon canisters, some claiming that canister maintenance would have to be allowed. These comments focused on: (1) carbon aging, (2) carbon deterioration, and (3) the effects of alcohol blends on activated carbon.

Response: The comments on the adequacy of canister sizing prompted EPA to use a detailed methodology to calculate required working capacities and the associated canister sizes. This methodology consisted of: (1) calculating an appropriate refueling emission rate for the test procedure now being considered by EPA, (2) applying this emission rate to projected fuel tank sizes, and (3) calculating the amount of carbon needed to control the emissions from these average fuel tank sizes.

The emission rate used to calculate average refueling emissions and to size carbon beds was developed from a series of uncontrolled refueling emission tests done at the MVEL in Ann Arbor in the winter of 1984-85. Over one hundred uncontrolled tests were performed on a set of six LDV's and two LDT's. The tests covered most applicable ranges of residual tank and dispensed fuel temperatures as well as a significant range of fuel volatilities as measured by Reid vapor pressure (RVP). A multiple linear regression was done on the results of the uncontrolled tests, to develop an equation to predict the emission rate for chosen conditions of temperature and RVP. The test program and the analysis of the results are thoroughly described in an EPA technical report, and will not be described here (I-A-69).

The emission rate regression equation uses three inputs to calculate an emission rate: (1) T_D, the temperature of the dispensed fuel, (2) ΔT, tank residual fuel temperature less T_D, and (3) RVP, fuel volatility measured as RVP. The values for temperature chosen for these variables are those given in the proposed refueling test procedure (I-A-71). The values were chosen by using available data to estimate 90th percentile conditions for T_D and ΔT for the ozone prone regions and ozone prone months. In other words, the ΔT and T_D conditions were chosen to be worse (in terms of emissions) than 90 percent of all refuelings during the ozone prone months of May through September in those regions. The fuel volatility was chosen to be representative of summertime in-use fuel in those regions. The draft recommended practice for the measurement of refueling emissions details the derivation of each of these values (I-A-71), so the analysis will not be repeated here. The parameter values used here are: T_D = 88°F, ΔT = 5°F, and RVP = 11.5 psi. Using these values, the equation predicts a refueling emission rate of 7.0 grams of hydrocarbon emitted per gallon of fuel dispensed. This emission rate was used to size canisters. If the RVP equals 9.0 psi, the emission load is 5.8 grams per gallon.

This emission rate was then applied to average fuel tank sizes for LDV's and LDT's. The fuel tank sizes were chosen by assuming an average single tank driving range of 300 miles, and applying the average vehicle fuel economy (from the MOBILE3 Fuel Consumption Model) for the chosen year to the 300 miles (I-A-99, I-B-37).* This gives an average tank size for each vehicle class and model year of interest. For the refueling test procedure it has been assumed that a worst-case fueling would require no more than a 90 percent fill and, therefore, carbon canisters are sized to only 90 percent of the 300-mile driving range capacity. The calculation of the fuel tank capacities is shown in Table 2-1. For 1989, the average LDV fuel tank capacity was estimated to be 12.2 gallons (90 percent = 11.0 gallons). The average LDT fuel tank capacity in 1989 is estimated to be 16.3 gallons (90 percent = 14.7 gallons).

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*Fuel tank size projection data supplied by two manufacturers after the close of the comment period on the gas marketing study indicate that fuel tank sizes may not decrease significantly in the future as fuel economy improves. This in turn argues that vehicle downsizing will not be a significant source of fuel economy improvement in the future. If this is the case, then average fuel tank sizes will be 10-20 percent larger than those used here.

The calculation of the necessary hydrocarbon storage capacity can be completed by simply multiplying the predicted emission rate by 90 percent of the projected average fuel tank capacities. The projected gasoline working capacities (in grams) that went into the calculation of onboard system costs are shown below:

	LDV	LDT	LDT (dual tank)
1989	77	103	205
1994	71	100	198
2000	65	92	183

Some commenters felt that the working capacity of activated carbons might have been overestimated in sizing the canisters in Appendix C of the July 1984 analysis. In order to avoid this problem, EPA has derived an appropriate gasoline working capacity from carbon manufacturers' specifications for their carbons. The carbon EPA has chosen to evaluate is Westvaco, extruded carbon. This carbon was chosen because it has a relatively high butane working capacity (10.5 g/100 ml) and can be produced to cause a low pressure drop through the canister (the issue of system backpressure will be discussed in a following paragraph). This is not meant to imply that other carbons (wood, coal, or coconut-based) are not acceptable. They simply would have different working capacities and different pressure drop characteristics.

The butane working capacity was corrected for the difference between butane and gasoline vapors and for carbon aging. "Carbon aging" refers to the process by which activated carbons lose working capacity with successive load/purge cycles until a stabilized level is reached. The fraction of the initial working capacity at which stabilization is achieved is not known with certainty. The EPA was quoted estimates

Table 2-1. CALCULATION OF FUEL TANK CAPACITIES FOR VARIOUS YEARS

	LDV			LDT*		
	1989	1994	2000	1989	1994	2000
Driving Range (mi)	300	300	300	300	300	300
Fuel Economy (mi/gal)	24.61	26.64	29.13	18.43	18.99	20.56
Fuel Tank Capacity (gal)	12.2	11.3	10.3	16.3	15.8	14.6

*The fuel tank capacities for LDT's with dual fuel tanks were estimated by doubling the LDT values.

ranging from 60-75 percent by carbon manufacturers. To be conservative, EPA used 60 percent in this analysis. At this point, an additional safety factor of 10 percentage points was also applied. Therefore, the virgin working capacity was reduced by 50 percent to reflect aging and a moderate factor of safety. The aged butane working capacity is then (10.5 grams HC/100 ml) x 0.5, or 5.25 g/100 ml.

Gasoline working capacities are generally expressed as some fraction of butane working capacities. Depending on the source, the fractions quoted range from 60-85 percent. In order to provide a liberal estimate of the amount of carbon needed, the lower bound of this range, 60 percent, was used. Thus, the aged gasoline working capacity of the Westvaco extruded carbon has been estimated to be 3.15 grams HC/100 ml carbon (0.60 x 5.25 g/100 ml). The canister sizes were found by dividing required hydrocarbon storage capacity from above by the aged gasoline working capacity of the Westvaco carbon. Carbon canister sizes, in milliliters, are shown next:

Year	LDV	LDT	LDT (dual tank)
1989	2,440	3,260	6,520
1994	2,240	3,150	6,300
2000	2,060	2,900	5,800

It should be noted here that in an attempt to estimate costs conservatively the necessary refueling capacity was added to the existing evaporative capacity. Therefore, the carbon bed sizes shown above would be larger by the current evaporative control capacity.

The comments on the effects of alcohol on activated carbons are related to the concept of carbon aging. Some commenters felt that the increased use of alcohols in fuels could increase the size of the canister heel and thus reduce the total canister vapor capacity in-use. There is little evidence available to support this assertion. The EPA has conducted two separate test programs to evaluate whether alcohols reduce carbon working capacity (I-A-107, I-A-108). In each case the test programs have led to the conclusion that alcohol has little or no effect on the canister working capacity, and no long-term loss in working capacity can be traced to the presence of alcohols. Based on the information presently available, it is reasonable to conclude that alcohols do not cause a significant decrease in working capacity with time.

The commenters who felt that canister maintenance would be required expressed concern over: (1) deterioration of carbon particles, (2) reduction in working capacity through aging, and (3) canister poisoning. The concerns about the deterioration of carbon particles with time were expressed by a single commenter. This commenter's concerns were based on examination of evaporative control systems from in-use vehicles which showed that a number of them were inoperative. In some cases, further inspection of the non-functioning systems showed that pulverized carbon particles were blocking vapor lines or canister orifices on some of the vehicles. The commenter claimed that similar problems would arise in onboard systems and that canister maintenance/ replacement would be necessary to resolve this problem.

The key to avoiding problems with this type of carbon deterioration is proper canister design, internal packaging, and canister filling technique. If the canister internal design is proper to prevent shaking of the carbon bed during vehicle operation and to prevent any pulverized carbon from reaching key orifices, then problems such as described by the commenter should not occur. This involves proper filling technique to prevent settling of the carbon granules in-use and the use of internal foam or fiber separators to further pack and restrict the carbon bed. The canisters examined in the study were from vehicles produced in the first half of the 1970's, during the early stages of evaporative emission controls. The canister filling process and internal canister design has improved since that time and deterioration of carbon particles should not be a significant problem and has not been found to be a problem on other vehicles tested in EPA's emission factors program.

Carbon aging was defined above as the decrease in total hydrocarbon storage capacity with time, normally during the first one hundred or so load/purge cycles of its use. The working capacity of a carbon bed will decrease initially, as one commenter pointed out, but it will stabilize and remain relatively constant at that level in the future. As discussed in the paragraphs above, working capacity was reduced by 40 percent (based on carbon manufacturers' suggestions) to allow for carbon aging. If carbon aging is accounted for in carbon canister designs, there should be no need for canister maintenance or replacement as long as the carbon is not poisoned.

Carbon poisoning occurs when liquid fuel is allowed to flow through vapor lines and into the carbon bed. If the large hydrocarbon molecules in the liquid fuel (which are only present in small quantities in vapor) reach the canister and are adsorbed onto the carbon bed, they are unusually difficult to desorb. This problem can be avoided by including a liquid/vapor separator in the vapor line between the fuel tank and the carbon canister. If such a device is included, canister poisoning should not be a significant problem.

There were only a few comments that claimed that canister maintenance would be required. There does not seem to be general concern over the ability of carbon canisters to last the full life of a vehicle. In a recent EPA final rule (50 FR 10606, March 15, 1985), EPA increased the LDT maintenance interval for evaporative control canisters to 100,000 miles. The comments to the NPRM for this rulemaking contained only passing reference to the increase in the maintenance interval (I-D-318). The general lack of concern shown about the difficulty of meeting a maintenance interval of 100,000 miles indicates a general agreement on the part of the auto industry that canister deterioration for well-maintained vehicles is not an issue, and canisters can be designed to last for the full life of an LDV, LDT, or HDGV.

Some commenters felt that the large onboard canisters would induce an unmanageable fuel tank backpressure when refueling vapors are forced through at 8 to 10 gallons per minute. Backpressure in the fuel tank during refueling is influenced by a number of factors. These include: (1) activated carbon type, (2) mesh size of activated carbon, (3) vapor line diameter, (4) vapor line configuration, (5) limiting orifice size, (6) canister shape and the associated vapor path, (7) canister configuration - open or closed bottom, (8) canister location, and (9) fuel fill rate. A low backpressure is essential to the proper functioning of liquid seal systems, and the control of backpressure is discussed thoroughly in the EPA technical report referred to previously (I-H-158). The work done in testing the liquid seal systems shows that through proper material selection and system design it should be possible to keep backpressure at a manageable level.

c. Packaging

Comments: A number of auto makers expressed concern that adding onboard refueling vapor controls would introduce packaging problems and force them to make modifications to their vehicles. Some claimed they would have to relocate a number of components to accommodate onboard controls. Others claimed that the increased space requirements of onboard controls would force them to sacrifice cargo space or fuel tank capacity (I-H-22, I-H-53, I-H-100, I-H-104).

Response: Controlling refueling emissions from LDV's and LDT's would require adding a carbon canister between 2-1/2 and 5 liters (for 11.5 psi RVP certification fuel) in volume,* as well as various other related components. Mueller Associates examined packaging implications in their report on the costs of onboard vapor recovery hardware (I-A-77). Although the contractor's study was a limited survey of potential impacts on current vehicles, several conclusions can be drawn. First, for large and mid-size LDV's and most LDT's, packaging of onboard control systems is not a significant issue. For compact and smaller LDV's, some vehicle modifications might have to be made to accommodate the onboard components. These modifications might be as insignificant as relocating a few noncritical items or as involved as modifying fuel tanks or other vehicle sheet metal. It should be noted that these smaller vehicles would also have the smallest refueling canisters, so system packaging may not be as challenging as portrayed by the commenters.

Although tooling changes for current vehicle models that are not scheduled for major design changes may be relatively costly, it poses no threat to the feasibility of onboard controls. As time passes and new vehicle designs are planned, onboard controls would be included as one of many design criteria, reducing the impact of packaging concerns. As a short-term option, manufacturers may choose to marginally reduce cargo space or fuel tank volume on compact cars during the first few years of the regulation, but in the long run, onboard systems could be designed to use space efficiently and restore capacity. In conclusion, EPA recognizes that packaging of onboard systems might involve some engineering effort and expense and accounts for this in the cost analysis, but the problems it causes do not affect the technological feasibility of onboard controls.

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*Dual tank trucks might require larger canisters. See Cost Section 2.6.1 for derivation of required canister sizes.

2.1.5 Safety Concerns*

Comment: The commenters on the safety of onboard control systems addressed three main issues: (1) gasoline spillage and the need for a pressure relief mechanism, (2) fuel system integrity during accidents or vehicle rollover, and (3) potential hazards related to the carbon canister. The comments related to these topics are summarized below.

Many of the commenters reiterated the safety problems mentioned in the 1984 analysis regarding fuel spit-back and noted that it might be more difficult to solve these problems than EPA suggested. Commenters noted that pressure buildup could lead to fuel spillage and/or to the poisoning of the carbon canister if the liquid/vapor separator failed. The commenters pointed out that any spilled fuel could pose a fire hazard and would reduce the effectiveness of the control system. The commenters also noted that if gasoline were forced out through the fillneck seal, the fuel spit-back may fall on the nozzle operator. Many commenters also noted that even the proper functioning of a pressure relief device could cause some of these safety hazards.

A second major topic of comment was the integrity of the fuel system during accidents or vehicle rollover. Commenters noted that onboard systems would have to be designed to accommodate the high vapor flow rates associated with refueling, and this would involve larger vapor lines and associated orifices. Some changes would therefore have to be made to ensure that Federal fuel tank integrity standards (FMVSS 301) could be met. Some commenters claimed that this would require more than a simple enlargement of existing rollover valves (I-H-2, I-H-53, I-H-90, I-H-100, I-H-101, I-H-114, I-H-118, I-H-127). Also, one commenter noted that the connections needed to link the additional onboard vapor lines and valve(s) from the fuel tank to the carbon canister would create more chance for a loss of fuel system integrity during a vehicle accident.

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*1984 Federal Register topic.

A third area of comment concerned the carbon canister used to capture refueling emissions. These comments involved the possibility of the canister creating a potential fire hazard as a result of either canister rupture during a vehicle accident or canister removal in-use due to tampering.

Response: The following analysis summarizes the major engineering and design issues raised in the comments. A more detailed discussion of the safety implications of onboard controls, including applications of onboard to HDGV's, can be found in the EPA technical report available in the public docket (I-A-112). In response to comments on onboard technology, EPA has made a number of changes to the onboard control system concept described in the July 1984 analysis. Concerns about the safety of the original system were a major reason for many of these changes. Three features of the new system led to substantial improvements in its safety. These are the liquid fillneck seal, the refueling vent line valve(s), and the "soft" closing fill limiter.

The EPA has duly noted that there are a number of potential safety problems associated with pressure buildup during refueling of vehicles equipped with mechanical fillneck seals. While EPA still believes that an adequate pressure relief mechanism can be developed for these systems through direct engineering effort, it must be noted that the systems currently being analyzed by EPA do not use a mechanical fillneck seal. Rather, these systems use a liquid seal in the fillneck. As was discussed earlier, the liquid seal systems avoid all difficulties related to pressure buildup during refueling. Any abnormal increase in pressure will cause gasoline to back up in the fillneck and trigger automatic nozzle shutoff, as occurs on current vehicles. With a liquid seal system, the probability of fuel spit-back is no greater than with present vehicles.

While there are good reasons to be concerned about the effects of nozzle failure, there is no evidence to indicate that failures are or will be common or widespread. Discussions with nozzle manufacturers indicate that most failures of the automatic shutoff mechanism occur at the very low dispensing rates (<2 gallons per minute) which sometimes accompany persistent topping off attempts at the end of a refill. Any reasonably well-designed pressure relief valve should easily be able to handle the excess fuel dispensed in this situation. Thus, EPA does not believe that fuel spit-back will present a significant design or in-use problem for those manufacturers choosing to use mechanical seals.

A number of commenters suggested that the incidence of spillage at the time of automatic nozzle shutoff would increase if onboard controls were required. Their contention is that the fill limiting device needed for onboard systems would shut off abruptly when the gas tank became full, causing pressure in the tank to rapidly increase. The pressure would continue to rise in the tank until automatic nozzle shutoff occurred. Although the time between fill-limiter closure and nozzle shutoff would only be an instant, these commenters claimed that fuel tank pressure could build to well above normal levels, which could lead to fuel spillage even after automatic nozzle shutoff occurred.

This problem can be eliminated by using a fill limiter that closes gradually. There are a number of mechanisms that could be used to provide this "softer" close. One method is to use a less than perfect seal in the housing into which a float seats. Then, when the tank is full and the float "closes" the vent line, some vapor will still flow out of the tank through the fill limiter. Fuel tank pressure will not become excessive, gasoline will rise more slowly in the fillneck, and automatic shutoff will be smoothly triggered. It should take only a minimal amount of engineering effort to design a fill limiter with this type of "soft" close.

With regard to fuel spillage, it is worth noting that the draft onboard test procedure may actually lead to a reduction in the amount of fuel spilled in-use, and thus improve the overall safety of refueling events. In the refueling test, vehicles would have to be designed to accommodate a refueling dispensing rate of up to 10 gallons per minute (near the high end of current in-use values) without any fuel spit-back due to premature or final nozzle shutoffs. While shutoffs are permitted in the test, any fuel spilled as a result of the spit-back is considered as part of the test results (refueling emissions). Since one tablespoon of gasoline evaporates to about 10 grams of vapor, almost any spillage will result in a failure of the test. Thus, EPA believes that manufacturers will design fillpipes and fuel systems that allow no spit-back of fuel at refueling rates up to 10 gallons per minute. This will lead to a reduction in the amount of fuel spilled in-use and improve the safety of vehicle refueling.

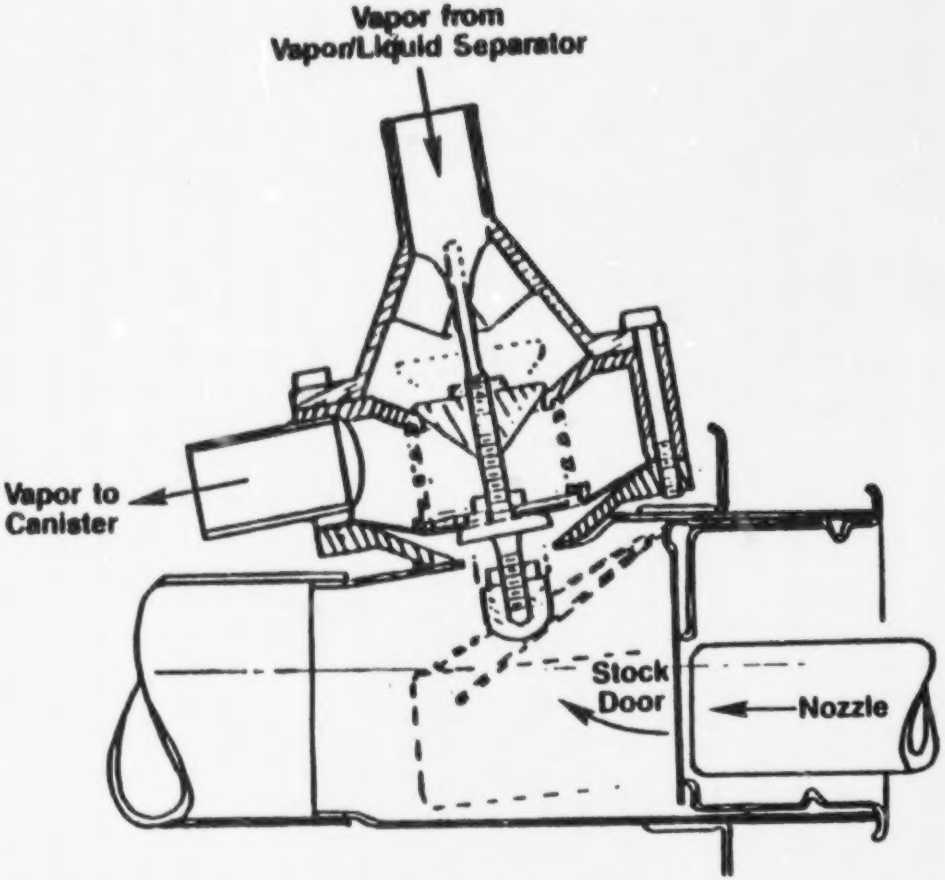
Adjacent to the fill limiter in the onboard system discussed above, is the refueling vent line closure valve. In the open position, this device provides a large orifice (which can accommodate the high vapor flow rates associated with refueling) and could also be designed to provide a limiting orifice when closed (see Figure 2-7). The valve is open whenever the fuel cap is not in place on the fillneck and is closed at all other times. When closed, the valve would serve to limit the loss of gasoline from the fuel tank during a vehicle rollover. This is the problem addressed by FMVSS 301, which requires a vehicle to restrict fuel leakage to less than one ounce per minute when rolled on either side or upside down following a front, rear, or side collision.

The refueling vapor vent closure valve must have one additional feature. It must be designed so that failure can occur only in the closed position. If the valve failed in the open position and rollover occurred, gasoline might escape from the vehicle's fuel tank and cause a fire hazard. Also, absent some other means, the vehicle owner would not know the valve had failed. If the solenoid valve failed in the closed position, it would be very difficult to fuel the vehicle. This would cause an inconvenience for the vehicle operator, but the fuel system integrity would be intact and there would be a strong incentive to have the vent closure valve immediately repaired.

The mechanical approach to the refueling vent valve demonstrated by API also addressed the need for vent line closure in the event of vehicle rollover (I-H-158). This kind of valve (Figure 2-9) is closed at all times except during refueling, and should therefore prevent the escape of fuel in a rollover incident. Only when the nozzle is inserted into the fillneck does the valve move to the open position, allowing vapor to leave the tank. A mechanical valve located at the vehicle/fillneck interface does present one safety concern that doesn't apply to the solenoid type valve. Because the valve is located near the exterior shell of the vehicle it could be susceptible to damage if struck in a collision. Although this is an issue that would have to be addressed by a manufacturer, it seems that the vent valve would be no more susceptible than the fillpipe or gas cap. This valve would have to be

Figure 2-9

NOZZLE-ACTUATED REFUELING EMISSIONS VAPOR VENT VALVE


Vapor from
Vapor/Liquid Separator
Vapor to
Canister
Stock
Door
Nozzle

From "Vehicle Onboard Refueling Control", API Publication No. 4424, March 1986.

designed with adequate structural integrity to fulfill its function in this situation.

Similarly, the vapor line connections to and from this and any other valves in the refueling control system would have to be designed to withstand the stresses that may occur in an accident. For example, when a force is applied during an accident, objects of different mass (vapor lines, valves) are accelerated at different rates. These connections and other vehicle component interface areas would have to be designed to withstand the effects of differential acceleration. However, EPA does not believe that this design consideration presents new or significant problems to manufacturers. Current vehicle fuel and evaporative emission control systems meet this requirement, and EPA believes that onboard systems can, with a reasonable amount of engineering effort, also meet the requirement.

Finally, several points can be made regarding potential safety hazards related to the carbon canister. The EPA understands concerns that a carbon canister ruptured during an accident may present a fire hazard, but this potential problem is no greater with refueling canisters than with evaporative emission canisters. There is no evidence that current evaporative emission canisters present a fire hazard, and EPA believes that refueling canisters can be used with the same degree of safety. Any lingering canister safety concerns can be addressed through placement of the canister in a more protected area such as the rear of the engine compartment or in some other under body area. While refueling canisters would be larger and more difficult to package in some cases, on a unit volume basis they would contain no more activated carbon or vapors than evaporative canisters.

Although not expected to occur, tampering that resulted in removal of the refueling canister conceivably could lead to a fire/explosion hazard under the vehicle hood immediately after the end of the refueling event. While the vapor mixture reaching the underhood area in this situation is above the gasoline upper flammability limit (6 percent), the mixture would briefly become flammable as the gasoline vapor dissipated. If a spark or other ignition source were present at that time, the mixture could burn briefly. While this problem is likely to be rare, there are two means to address it. First, placement of the canister in a location distant from ignition sources would eliminate the problem. Possible locations include the rear of the engine compartment or some underbody area. Second, a small label on the canister to discourage tampering may also be helpful. Nevertheless, canisters should not be placed in a location where tampering could create a safety problem. Overall, since canister tampering is uncommon and steps to eliminate potential problems do exist, EPA believes that this potential problem can be easily addressed.

2.1.6 Canister Purge

Comment: A number of commenters claimed that purging refueling vapors from the system canister would have a detrimental impact on exhaust emission levels, and that the results of the 1978 API demonstration program are not applicable to the vehicles of today because of more stringent emission standards and changes in vehicle technology. Other commenters claimed that the added purge requirements would lead to driveability problems (I-D-58, I-D-59, I-H-99, I-H-100, I-H-101, I-H-116, I-H-127). One of these commenters felt that driveability problems might induce onboard control system tampering (I-H-99). One commenter claimed that EPA had failed to account for the interaction of purged hydrocarbons and "live" vapors produced during vehicle operation (I-H-101). The commenter felt that vehicles' electronic controls might have to be modified to interpret and adjust to the incoming vapor mixture. Another of the commenters expressed a concern that vehicles equipped with onboard controls would not meet emission standards and probably would not perform well outside of the conditions encountered in the Federal Test Procedure (I-H-127).

Response: The EPA continues to believe that purge requirements for vehicles equipped with onboard controls can be met without an increase in exhaust or evaporative emissions. While many commenters expressed concerns in this area, no data or detailed technical analyses were provided to support these positions.

The American Petroleum Institute has sponsored two programs designed to evaluate the feasibility of onboard control systems. The first one, performed in 1978, is the one to which the commenters referred (I-F-17). In this program, three vehicles, certified to 1978 California emission standards, were equipped with prototype onboard control systems.

Although all the vehicles in this demonstration program were carbureted, and hence are not representative of the projected fleet makeup for the late 1980's and beyond, the program does have some useful implications. The vehicles, when equipped with onboard control systems, were able to pass the 1978 California exhaust and evaporative emission standards despite the fact that more hydrocarbons were being purged from the refueling canister than from the stock evaporative canister. The API did not demonstrate that purge was adequate to restore hydrocarbon storage capacity between refuelings, but it did demonstrate that these vehicles (equipped with older fuel system technologies) could handle increased emission loads and still pass emission standards.

The second API program was performed in 1985 (I-H-158). In this demonstration program, three 1985 model year vehicles were equipped with onboard control systems and tested under the recommended test sequence proposed in the EPA recommended practice published in July (I-A-71). Two of these vehicles were equipped with feedback controlled fuel injection systems and the third used a feedback controlled carburetion system. Each of the vehicles was able to pass the current exhaust and evaporative emission standards as well as the refueling requirements described in the recommended practice. The EPA has, however, revised the recommended test procedure since the publication of the July 1985 draft to more thoroughly test the adequacy of the vehicle purge systems (I-A-76). The API vehicles were designed only to pass the requirements in the July draft, however, and may not meet the more stringent purge requirements in the April proposal. The results of the 1985 demonstration do show that vehicles equipped with feedback fuel control can handle hydrocarbon loads (over the FTP) greater than those associated with evaporative canisters without major system modifications, and that required emission levels can be maintained.

The main technological issues surrounding the feasibility of onboard controls for feedback-equipped vehicles are the range of control and response time of the feedback systems. The 1985 API demonstration program showed that current feedback systems can adjust to some increases in purged hydrocarbons while maintaining acceptable exhaust emission levels. This demonstration supports EPA's belief that vehicles equipped with feedback fuel control systems could be designed to purge refueling canisters efficiently through modified purge systems and/or strategies.

A different situation arises for those vehicles that are not feedback controlled. As mentioned earlier, EPA projects that 88 percent of the fleet will be fuel-injected by 1990. Some of the carbureted vehicles will also use feedback controls, so only a small percentage of the fleet will be in this category. Discussions with a few auto manufacturers suggest that most of these vehicles are compact or subcompact cars positioned as the lowest-priced cars in the manufacturers' product line. The EPA believes that with some engineering effort, these small cars can be equipped with onboard controls and still meet exhaust emission standards without the addition of feedback fuel control. The reasons behind this belief are outlined in the following paragraphs.

First and foremost, the two 1978 API demonstration vehicles that were not equipped with feedback fuel control systems were able to pass the then current exhaust emission standards when retrofitted with onboard controls. The emission standards have been tightened since 1978, but vehicle emission control packages have improved to keep pace with the more stringent standards. If the emission control system of the mid-to-late seventies could meet exhaust standards with a retrofitted onboard system, it is likely that the more advanced emission control system of the eighties designed with the onboard purge requirement as an integral part of the control strategy would be able to meet current standards with some design modifications and system improvements.

Second, the size and weight of the typical non-electronically controlled vehicle make it more likely to meet the exhaust emission standards without substantial modification. As noted above, these vehicles are typically very small cars with small fuel tanks and a lower total refueling vapor load. Since the cars have better fuel economy than do heavier cars, they have a relatively greater driving range in which to purge a smaller hydrocarbon load. In addition, due to their lighter inertia weight these smaller cars usually pass emission tests at a lower emission level than do larger cars. That is, there is a wider gap between their emission levels and the standards. Therefore, these cars should be able to emit at a greater rate than they would without onboard controls, and still remain below applicable exhaust standards.

Because of the factors described above, EPA still believes that vehicles without electronic engine controls can be designed to include onboard systems and meet exhaust emission standards. In some cases, it will be an engineering challenge to design a non-electronic purge control system that will provide adequate canister purge and keep exhaust emissions and driveability within acceptable ranges. Although difficult, it appears feasible and, as mentioned above, the task will have to be undertaken only for a small fraction of vehicle models.

2.1.7 Excess Evaporative Emissions

Comment: One group of commenters concurred with the EPA position that it would be possible to control excess evaporative emissions using the excess capacity of the refueling vapor control system. Although no commenters denied the feasibility of controlling excess evaporatives through expanded adsorptive capacity, one commenter noted that purge rates would also have to be increased to purge the canisters of the extra vapors. This commenter went on to state that not all excess evaporative emissions can be controlled by increasing the purge and storage capacities of an onboard system. The same commenter notes that onboard systems with a separate carburetor canister would continue to emit excess "hot soak" emissions, even though the refueling canister had excess capacity. This commenter concludes that there are several possible techniques available to control excess evaporative emissions, and that the issue should be considered separately from onboard.

Response: At the time of the original publication of Appendix C, the problem of excess evaporative emissions was just being identified. The initial series of EPA evaporative emission tests seemed to show that vehicles that had been certified as meeting appropriate evaporative emission standards were exceeding this emission level in-use. Since the publication of the July 1984 EPA analysis, the evaporative emissions problem has been much more thoroughly investigated. All of this work is discussed in great detail in a recently published EPA study on fuel volatility and hydrocarbon emissions (I-A-66). In that study a number of sources of excess evaporative emissions were identified.

A large fraction of the excess emissions appears to be attributable to inadequate hydrocarbon storage (due at least in part to the increasing volatility of in-use fuels) and purge capacities. This fraction of the excess (hereafter referred to as "the controllable excess") can be controlled through the use of increased hydrocarbon storage capacity and purge system improvements. One method of requiring greater hydrocarbon storage capacities and purge system improvements would be to increase the volatility of the certification fuel and make other test procedure changes, thereby forcing automobile manufacturers to design control systems to capture and purge higher emission loads. The problem could also be addressed by a certification fuel change as part of an onboard regulation.

Although the excess evaporative emissions problem could be addressed as part of an onboard emission control rulemaking, EPA is currently considering several other strategies to obtain this control. Because the excess evaporative emissions problem could be addressed outside of an onboard regulation, EPA has focused the onboard analysis strictly on refueling emission control. That is, the costs, benefits, and cost effectiveness figures used in the evaluation of onboard controls as a hydrocarbon control strategy are incremental to those associated with the control of excess evaporative emissions. Related comments are discussed in Sections 2.6.4 and 5.1.

2.1.8 Test Procedure

Comment: A number of commenters stated that the lack of a proposed test procedure made it difficult to comment on the technological feasibility of onboard controls. Commenters claimed that they could not proceed with onboard control system development without some idea of the demands of the test procedure. They also stated that they could not accurately project what technological barriers might be encountered in control system development without a complete description of the refueling test conditions and some idea of what emission levels would be allowed. A few commenters gave suggestions on possible test procedure conditions and methods.

Response: The EPA agrees that there could be some difficulties for a manufacturer in developing an effective onboard control system without a knowledge of at least some of the likely specifics of the refueling test procedure. The EPA understood the desire for a recommended test procedure at the time of publication of the July 1984 analysis, but was still in the process of developing the details of the procedure. In response to the manufacturers' concerns, EPA held a workshop on October 17, 1984, to present some preliminary ideas for a refueling test procedure. The recommended draft refueling test procedure was completely described at the workshop (I-B-28). The EPA described the methodology behind the development of the draft test procedure, the selection of critical test procedure parameters, and the selection of appropriate values for those parameters. Since the public comment period closed on November 8, 1984, at least some commenters were able to include some information on a possible test procedure requirement in their comments on the July 1984 EPA analysis.

At the October 1984 workshop, EPA asked the automobile manufacturers to prepare comments on the recommended test procedure drafted in 1984. Several groups did comment on the procedure and the Motor Vehicle Manufacturers Association also presented their comments orally to EPA in February of 1985. The EPA then published a recommended test procedure in July of 1985. Comments were accepted in response to the July publication. Following EPA's evaluation of those comments and a reanalysis of the test procedure requirements, the draft recommended procedure was changed substantially. The changes in the procedure were presented to the industry at the most recent test procedure workshop on April 10, 1986. Although the development of a refueling test procedure has been an evolutionary process, and the procedure has not been finalized, the intent and the basic structural components of the procedure have been clear for some time. The EPA has been working to improve the procedure to provide an adequate test of system capabilities with minimum resource requirements. Although these improvements may result in changes to the details of the procedure, they should not affect the basic emphasis of the procedure, the necessary control technology, or the ability of auto manufacturers to proceed with control system development.

2.1.9 Miscellaneous

The EPA received a number of isolated comments on minor issues which are significant enough to merit response. This section summarizes these comments and provides a brief response to each.

a. Hydrocarbons Emitted at Fuel Cap Removal and Running Losses

Comment: Various comments were received which described the phenomenon of "pop" and "hiss" emissions. Pop emissions are vapors emitted when the fuel cap is removed. Hiss emissions are those emissions that are released from the fuel tank by the gas cap pressure relief during vehicle operation. Some commenters simply stated that EPA should further examine the phenomenon. Some claimed that onboard could control these emissions and felt that the magnitude of these emissions should be determined and this amount should be credited to onboard control strategies. Others felt that onboard could not control these emissions and the efficiency of onboard controls should be reduced to reflect this loss. A few commenters mentioned "hiss" emissions as a source of emissions that had been excluded from the original analysis without justification (I-H-33, I-H-35, I-H-40, I-H-44, I-H-46, I-H-69, I-H-76, I-H-85, I-H-87, I-H-89, I-H-96, I-H-97, I-H-102, I-H-105, I-H-106, I-H-108, I-H-109, I-H-110, I-H-119, I-H-120, I-H-121, I-H-123).

Response: The EPA recently ran a series of tests to evaluate the severity of the popping emissions problem. The test program and data analysis are discussed in a technical memo which has been included in the public docket (I-A-97). The evaluation showed that "pop" emissions of a significant magnitude (i.e., 2 or more grams) do not occur frequently enough to justify giving the problem further consideration at this time. The analysis showed that only at high tank temperatures and with high volatility fuels do appreciable pop emissions occur. It also showed that these events occur for less than 5 percent of all refueling events. Therefore, the total hydrocarbon inventory associated with "pop" emissions is very small and can be excluded from the onboard analysis.

Currently, there is no test information available with which to assess the magnitude of hiss emissions, although some work is planned for the future. Because these emissions occur during operation of the vehicle, it is difficult to isolate and measure them. The EPA has conducted an engineering evaluation to determine if fuel caps are likely to vent to the atmosphere during operation under extreme temperature conditions (I-B-19). Although the limiting orifice between a fuel tank and its evaporative canister is often no larger than forty thousandths of an inch, the study shows that tank venting is unexpected. However, due to the wide variety of vehicle designs and higher in-use fuel volatilities, some testing work is planned in this area.

b. Nozzle Modifications

Comment. Several commenters felt that gasoline dispensing nozzles would have to be modified to include a pressure relief device to prevent fuel tank over-pressure during refueling of onboard controlled vehicles (I-H-74, I-H-90, I-H-111, I-H-114, I-H-118, I-H-127).

Response: The EPA has discussed the existence of a potential problem with fuel tank over-pressure during the refueling of vehicles equipped with a mechanical fillneck seal (Section 2.1.5). These problems do not, however, arise during the fueling of vehicles equipped with liquid fillneck seals. Therefore, no pressure relief device is needed for liquid seal equipped vehicles.

If mechanical seal systems were to come into widespread use, it would be possible to achieve pressure relief through nozzle modification. Though possible, this does not appear to be the optimum approach. If a manufacturer chose to use a mechanical fillneck seal, the manufacturer may have to include a vehicle-based pressure relief device, or else a voluntary uniform nozzle modification would be required. This does not seem likely, and a regulation requiring such modification would not be desirable. Thus, a vehicle-based pressure relief device is preferred. However, if deemed necessary, EPA is open to voluntary uniform nozzle standards to address dispensing rate limits or standardize nozzle geometries. Additional information concerning this issue can be found in an EPA technical report available in the public docket (I-A-111).

2.2 EFFECTIVENESS OF ONBOARD CONTROLS

A number of commenters, representing the automobile industry and other Stage II proponents, felt that EPA had overestimated the efficiency of onboard controls. These opinions were counterbalanced, however, by a number of commenters, largely representative of the petroleum industry, who accepted the EPA efficiency estimates presented in the July 1984 analysis. The latter analysis projected a new system efficiency of 98 percent, which might be reduced by tampering and possibly by deterioration to an in-use efficiency of 92 percent. Those commenters who disagreed with the EPA efficiency estimates based their objections on: (1) what they perceived to be portions of total refueling emissions that would not be controlled by onboard controls, and (2) factors affecting onboard control systems that they claimed were not considered or were inadequately considered in the EPA analysis. They predicted that the combination of all of these elements would greatly reduce the efficiency of onboard controls. Specific categories of comments on the control effectiveness of onboard are summarized and addressed separately below. These include: (1) onboard control for HDGV's, (2) breathing losses, (3) gasoline spillage, (4) onboard in current Stage II areas, (5) control system tampering, (6) canister system durability, (7) purge effects on system efficiency, and (8) overall control system efficiency.

2.2.1 Onboard Controls for HDGV's

Comment: Several auto industry commenters stated that since onboard controls would not be applied to HDGV's and motorcycles, the in-use efficiency of the onboard strategy would be reduced (I-H-2, I-H-107, I-H-114). Another commenter stated that use of Stage II controls would affect all kinds of vehicles and thus avoid any "problems" resulting from the exemption of certain types of vehicles (i.e., trucks and vans) from control (I-H-100).

Response: Although the July 1984 EPA analysis concentrated primarily on LDV's and LDT's, EPA did not intend to imply that HDGV's would be excluded from consideration if a decision were made to proceed with onboard controls. In fact, Appendix C addressed onboard controls for HDGV's, but implementation of an onboard requirement for these vehicles was not included in the July 1984 analysis, since the focus of the entire analysis was on the public gas marketing sector which covers primarily LDV's and LDT's.

The EPA concurs with the commenters who claimed that not controlling HDGV emissions would reduce the overall effectiveness of onboard by about 5 percent, since that percentage of the highway gasoline consumption would remain uncontrolled. In response to these concerns, EPA has included HDGV controls in the re-analysis; the basis for the costs and other factors used in the reanalysis is discussed in Section 2.6.

It is clear that onboard controls could be applied to most if not all HDGV's expected in the 1990's and beyond. Lighter GVW HDGV's are similar in configuration and usage to LDT's. These lighter HDGV's comprise over 75 percent of the HDGV fleet and would be easily adaptable to onboard control utilizing LDT components. There is also no reason that onboard controls could not be applied to the heavier HDGV's as well, although the cost would be higher than those for the lighter models since the necessary control system components would be larger and possibly more complex. Also, since the emission control systems on these vehicles will not be as sophisticated as for the lighter HDGV's, purge control and exhaust interaction effects would be more difficult to address. Thus, as discussed previously in the Strategies Document, it may be wise to evaluate the cost effectiveness of onboard controls for various GVW HDGV classes as part of the decisionmaking process.

2.2.2 Emptying Losses

Comment: Several commenters stated that onboard controls would not control service station storage tank breathing (emptying) losses, which would reduce the overall onboard efficiency (I-H-74, I-H-82, I-H-111, I-H-114, I-H-118).

Response: Fuel tank breathing losses (more correctly referred to as emptying losses) occur when liquid gasoline in the service station underground tank evaporates. This evaporation occurs because ambient air enters the underground tank during each refueling to replace the dispensed fuel, and this air becomes saturated with vapors. The rising pressure in the tank causes an escape of vapors through tank vents. While data and information in this area are very scant, EPA has assumed that Stage II controls would reduce this evaporation since the refueling vapors returned underground would at least partially saturate the ambient air entering the tank.

However, this should be viewed as an increase in reductions for Stage II, and not a decrease in onboard efficiency. Onboard efficiency in controlling refueling losses is not decreased by emptying losses. In fact, emptying losses, to the degree that they do occur, would not be affected by onboard controls at all.

2.2.3 Gasoline Spillage

Comment: A number of commenters stated that the efficiency of onboard controls would be reduced by fuel spills. These concerns were primarily related to the effects of nozzle failures and tank overpressures (I-H-111, I-H-114). One commenter expressed concerns about fuel spills resulting from tank overfills also flooding the carbon canister (I-H-111).

Response: The above comments are predicated on the assumption that a mechanical seal will be used to seal the pump nozzle-to-fillpipe interface. However, EPA believes that most manufacturers would opt for the liquid seal approach to avoid these potential problems. In the event of a nozzle failure, with a liquid seal system the motorist or service station attendant could see the liquid backing up in the fillpipe and release the trigger on the pump nozzle to stop the flow. As Ford correctly pointed out, this is the current practice with present conventional fillpipes and results in "very little spillage" (I-H-114). EPA sees no reason why spillage should be any greater with liquid seal onboard control systems than with current conventional fillpipes. Consequently, spillage was not a part of the efficiency calculation.

It is true that with mechanical elastomer seals, the tank could be pressurized in the event of a nozzle shutoff failure, and that manufacturers may want to incorporate a pressure relief valve in the system to forestall such eventuality. Moreover, the use of a mechanical seal does not inherently create the potential for spillage. Some other event such as a persistent topping off, vent blockage, or nozzle failure must occur. In these cases, the pressure relief valve would be activated, the operator would notice the spill, and fuel flow would be stopped. In fact, it could be argued that a mechanical seal could reduce overall spillage, because spillage due to premature shut-offs would be contained within the fillpipe.

It should also be noted that EPA believes that the potential for fuel spills due to nozzle failures is greatly overstated by the commenters. Discussions with several nozzle manufacturers indicate that nozzle "failures" occur at very low dispensing rates (<2 gpm) and not at the 12 gpm dispensing rate indicated by one commenter. With normal refueling technique, spills should not be an issue. Failures caused by persistent attempts at topping off should be minimized by the use of a pressure relief device on mechanical seal systems.

Concerns about fuel spills are also addressed by the onboard test procedure being considered by EPA. In that procedure, a vehicle must be refueled from 10 percent to automatic shutoff at a gasoline dispensing rate of up to 10 gallons per minute. Under the procedure, any spills which occur would be measured as part of the refueling emissions. Since even a tablespoon of spilled gasoline evaporates to about 10 grams of vapor, onboard systems will have to be designed to ensure no spillage. For this reason, it might be argued that onboard would reduce gasoline spillage. At this point, a potential increase in onboard efficiency due to decreased spillage (0.15 g/gallon) has not been considered in the onboard efficiency estimate (I-A-100).

Finally, EPA also expects that most onboard configurations would incorporate a float valve in the vent line to the canister to prevent overfilling the tank. This float valve, plus the liquid/vapor separator, would also act as a check valve to prevent flooding the canister under the circumstances mentioned by Hasstech.

2.2.4 Onboard in Current Stage II Areas

Comment: Three commenters stated that the EPA analysis credited onboard controls with emission reductions that should be attributed to Stage II controls that are already in place (i.e., in California and Washington, D.C.) (I-H-104, I-H-114, I-H-127).

Response: The commenters were correct in noting that the EPA onboard analysis issued in July 1984 included control of gasoline consumption in California and Washington, D.C. Since these areas already have Stage II in most areas (some portions of California do not have Stage II), it could be considered as unnecessary control or double counting to include onboard for these areas. In the reanalysis, onboard control for California vehicles was not considered in one scenario; thus, a 49-state onboard approach is also evaluated. Not equipping California vehicles with onboard controls is considered a feasible option since California accounts for more than 10 percent of new vehicle sales each year, and California already has different emission control requirements for vehicles registered there.

On the other hand, Washington, D.C. -- which is a much smaller area and represents a tiny fraction of the total highway gasoline consumption (less than 0.2 percent as opposed to almost 11 percent for California) -- has no separate emission control program and would not be exempted from an onboard requirement (I-F-134). This would not result in any significant duplication of effort, however, since Stage II equipment in the District of Columbia is largely first generation and is not particularly efficient even if well-maintained. Any credit given to onboard for emission reductions from Stage II would be very small and would not noticeably affect the overall effectiveness calculation. Onboard efficiencies would therefore not include any significant areas that were subject to Stage II controls. Thus, there would also not be any appreciable double-counting of costs as a result of implementation of onboard controls, as stated by Honda.

Similarly, the impact of expected Stage II reductions in the St. Louis, Missouri, area -- where Stage II is just beginning to be installed -- is not now (and will not be) great enough to significantly affect the overall (i.e., national) effectiveness of onboard.

2.2.5 Control System Tampering

Comment: Commenters who disagreed with EPA's estimates of new system efficiency and in-use efficiency stated that EPA had underestimated or neglected to consider the effects of a number of sources of reduced efficiency.

A number of commenters felt that EPA had not sufficiently considered the effects of deterioration and tampering on fillpipe seals (I-H-2, I-H-11, I-H-22, I-H-57, I-H-99, I-H-100, I-H-101, I-H-104, I-H-114, I-H-116, I-H-127). A number of commenters felt that the use of alcohol blend fuels would increase seal deterioration (I-H-101, I-H-114, I-H-116, I-H-127). One commenter felt that fillpipe seals could encourage tampering by making refueling operations more difficult (I-H-99). One commenter felt tampered fillpipe seals would be harder to repair (I-H-2).

On the other hand, several commenters felt fillpipe seals would make tampering more difficult (I-H-41, I-H-46, I-H-71, I-H-76).

Other commenters felt that fillpipe seals might not be compatible with existing Stage II nozzles, e.g., in California, and that this issue should be addressed (I-H-114, I-H-118, I-H-127).

Response: Most of these concerns noted in the comments apply to elastomer seals located in the upper part of the fillpipe. As stated previously, EPA believes that the use of this type of seal will not be common, with most manufacturers opting for the simpler and inherently more reliable liquid seal approach. The liquid seal approach would obviate almost all of the aforementioned objections. Nevertheless, some manufacturers may choose the elastomer seal approach, so a response to these comments will be made.

Design of an efficient seal would not be difficult. The API system demonstrated in 1978 used an off-the-shelf seal with only minor adaptation to the fillpipe (I-F-17). These seals have shown excellent initial efficiency, on the order of 98 to 99 percent, and little if any loss of sealing efficiency to 65,000 miles in a range of climatic conditions.

There is no evidence that alcohol blend fuels would affect the durability of an elastomer seal. In fact, one vehicle in the aforementioned 1978 API program ran 12,000 miles on an alcohol blend with no effect on the elastomer seal. If contradictory evidence is found, EPA believes that any such problems could be eliminated through proper choice of seal material.

The EPA agrees with the commenters who stated that fillpipe seals would make tampering more difficult. The elastomer seal would be more difficult to remove than a leaded fuel restrictor flap, for example. In some designs, the presence of the seal in the fillpipe would essentially eliminate the need for a leaded fuel restrictor as the fillpipe seal guide would have to be sized to be compatible with the unleaded fuel nozzle. With the liquid seal approach, the seal would be located in the tank rather than in the fillpipe, making it impossible to tamper with or remove.

The EPA agrees that repairing a tampered elastomer seal would be difficult, but no more so than repairing a tampered leaded fuel restrictor would be, since replacement of the fillpipe would be required in almost any imaginable instance.

Finally, seal compatibility with Stage II pump nozzles would be no problem in California, if onboard were required in that State. With the liquid trap approach, the top part of the fillneck would be virtually identical to current uncontrolled fillnecks, so there would be no change from current new vehicles. Even if an elastomer seal were to be used, proper design and placement would assure compatibility with Stage II refueling equipment. There is no reason why a properly designed onboard system would be incompatible with Stage II pump nozzles.

2.2.6 Canister System Deterioration

Comment: Several commenters stated that the adsorption capacity of the activated carbon in an onboard system would deteriorate with use, necessitating frequent replacement (I-H-58, I-H-90, I-H-111). One commenter stated that canisters would either fail or their efficiency would be reduced after repeated adsorption/desorption cycles due to buildup of heavier hydrocarbons that are not easily desorbed (I-H-58). Another commenter stated that the efficiency of the canister would decrease 5 percent with each adsorption/desorption cycle, thus necessitating replacement at 10,000-mile intervals (I-H-111).

Response: The EPA recognizes that charcoal canisters undergo an initial break-in period wherein a portion of the virgin working capacity can be lost. However, following the initial buildup of this "heel," data indicate that the working capacity of the canister stabilizes and deteriorates very little, if at all, thereafter. As explained elsewhere in this document, EPA expects that manufacturers will design their canisters with sufficient excess capacity to compensate for heel buildup, and this requirement has been considered in the onboard cost estimates. Claims of total canister failure after 10,000-20,000 miles or after 20 adsorption/desorption cycles are clearly refuted by both manufacturers' certification testing programs for evaporative emissions and the results of EPA in-use evaporative emissions testing programs. After development of the initial heel, canister deterioration is negligible unless poisoning or malmaintenance/abuse occur.

2.2.7 Purge Effects on Efficiency

Comment: A few commenters stated that a requirement for onboard controls could add to the present problems involved in canister purging, thereby reducing system efficiency (I-H-53, I-H-95, I-H-101). One manufacturer maintained that, since desorption is a nonlinear process, it is difficult to achieve control over the purging of present evaporative emissions, particularly with the higher RVP fuels prevalent in recent years. An onboard requirement would further compound the problems involved (I-H-101). Two commenters felt that more precise and sophisticated control of purging would have to be developed, likely including modifications to the control logic system (I-H-53, I-H-101).

Response: The EPA agrees that the purge requirements for onboard systems will be different from, and somewhat greater than for, current evaporative emission control systems, due to the increased volume of vapors involved. However, given the current state-of-the-art in feedback control systems, the Agency does not believe the problem is as difficult as has been stated by Chrysler (I-H-101). Since the problem is essentially one of purge air volume and mixture control, EPA does not believe that new vapor sensor technology needs to be developed. Most present sensors are capable of achieving the necessary control, and although some modifications to purge control logic systems may be required, the problems are essentially calibration problems rather than new design problems. The fact that only two manufacturers commented on the issue indicates that the industry as a whole does not consider the problem involved to be a particularly troublesome one. The EPA believes that sound engineering can eliminate any driveability or excess exhaust emission problems and that there should be no increased incidence of tampering.

For further discussion on the effects of purge on exhaust emissions and driveability, the reader is referred to the onboard technological feasibility analysis contained in this document (Section 2.1.6).

2.2.8 Overall Control System Efficiency

Comment: Several commenters felt that EPA's estimated onboard efficiency levels were too high in view of recently disclosed problems with in-use evaporative emissions (I-H-101, I-H-114, I-H-127). One commenter stated that EPA's projected in-use efficiency of 98 percent without tampering was inconsistent with the current evaporative control system performance as modeled in MOBILE3. The commenter suggested an efficiency of 88 percent would be more appropriate because the EPA-predicted in-use efficiency of 92 percent did not account for production variation, defects not remedied through warranty or recall, atypical operation which may produce system leaks, and canister poisoning by alcohol blend fuels (I-H-114).

Another commenter said that system effectiveness depends on fill-pipe-to-nozzle interface and control technology design and that efficiency could not be calculated until system design was finalized. Nevertheless, this commenter predicted an efficiency of only about

77 percent (I-H-116). Along the same lines, another commenter maintained that EPA's projected control efficiency was based on the results of a few API tests of a vehicle with an incomplete system. This commenter suggested an efficiency of 90 percent or less, based on 1978 GM comments, which in turn were based on 1973 SHED tests (I-H-127).

Response: Some of the commenters did not make a clear distinction between new system efficiency (the 98 percent figure projected by EPA), which is the average efficiency of a new control system absent tampering and deterioration, and in-use efficiency (the 92 percent EPA figure used in the July 1984 analysis (I-A-55), which does include potential deterioration and tampering. Each of these factors is discussed below.

a. Theoretical Efficiency

The July 1984 EPA analysis projected a new system efficiency of 98 percent based on 1978 API and EPA test data on a system that used an elastomer seal. Subsequent 1984-1985 EPA tests using a liquid trap indicate new system efficiencies from 95 to 99 percent, with the majority of the data falling into the 96 to 98 percent range (I-A-93). Based on this more recent and more substantial body of test results as well as on the earlier data, it is reasonable to assume an average new system efficiency of at least 97 percent. New control system efficiencies higher than this are clearly feasible (I-H-158). In their vehicle demonstration programs, API has demonstrated prototype system efficiencies of 99 percent.

For purposes of comparison, it is interesting to note that these results are consistent with new system efficiencies for evaporative control systems. From the 1984 model year certification data, which indicate certification levels for evaporative emissions ranging from 0.3 to 1.8 grams per test, it appears that the mean certification level would be about 1.4 to 1.5 grams per test (hot soak plus diurnal). Deterioration factors are included in these levels where applicable. Given the MOBILE3 level for uncontrolled vehicles of about 40 grams per test, these certification levels would equate to new system efficiencies of 96 to 97 percent, or possibly greater, since the certification data include deterioration.

The EPA recognizes that there will be a certain amount of production variability, which could affect new system efficiency, but it will be random in nature, with some vehicles exhibiting efficiencies that are higher than the norm and others showing lower efficiencies. As long as the vehicles in question are capable of meeting the established standard, EPA is not concerned about such variability. The effects of such variability are accounted for in the Agency's Selective Enforcement Audit (SEA) and in-use audit programs and would also be considered in the level of any onboard refueling emission standard. If systematic bias due to production defects should manifest itself, there are other remedies available to the Agency to ensure compliance.

In-use efficiency is calculated by applying appropriate factors to the new system efficiency to account for deterioration, tampering, and malmaintenance and defects. The July 1984 EPA analysis did not calculate a separate deterioration factor for onboard emissions, under the presumption that any deterioration would be insignificant and would likely be overwhelmed by the tampering rate, which was a composite of both canister and fillpipe tampering.

As stated earlier, EPA now believes many manufacturers will utilize the liquid trap approach, rather than an elastomer seal, which would virtually eliminate fillpipe tampering as a source of control performance degradation. The likelihood of diminished fillpipe tampering is also reinforced by the recent nationwide trend toward decreases in the unleaded to leaded fuel price differential caused by EPA's lead phase-down requirements (I-F-146). A lower differential reduces the incentive to tamper. Therefore, only the charcoal canister and hose tampering rates plus malmaintenance and defects in these areas will be used in calculating the revised in-use efficiencies. Since the canister and hose tampering rates are considerably lower than the composite rates used previously, it is now deemed appropriate to consider using separate deterioration rates.

b. Deterioration

Since onboard systems have only been demonstrated in vehicle prototypes, there is still a scarcity of data regarding the deterioration of onboard control systems. However, given the similarity of onboard control systems to current evaporative systems, it would be reasonable to use evaporative system deterioration factors (DF's) as a basis for modeling the deterioration in onboard systems. It was decided to limit the data for modeling onboard DF's to evaporative DF data from fuel-injected vehicles. Fuel-injected vehicles have no float bowl hardware, as do carbureted systems, and consequently generate no significant hot soak emissions. Therefore, the DF's for such vehicles would represent only canister and hose deterioration and would not include any induction system component deterioration.

The 1984 model year certification data indicate that the majority of evaporative control systems from fuel-injected vehicles exhibit no deterioration and that the DF's are very small for those families that do show some loss of control (I-A-73). Of a total of 59 fuel-injected LDV evaporative emission families and four fuel-injected LDT families, only six had evaporative emission DF's. The average DF at midlife (50,000 miles for LDV's and 60,000 miles for LDT's) is 0.08 grams per test for LDV's and 0.052 grams per test for LDT's. The LDT DF was extrapolated from the 50,000-mile data, since the useful life period for LDT's changed for the 1985 model year. For all 59 families considered the average DF was less than 0.01 g/test. This clearly demonstrates that canister and hose system deterioration is negligible for well-maintained vehicles. Over 90 percent of the families in this sample had no evaporative emissions deterioration, which indicates that zero deterioration is feasible and a reasonable assumption.

The potential effects of alcohol blends on canister durability are discussed in detail in the technological feasibility discussion presented earlier (see Section 2.1.4). The basic conclusion presented there is that no evidence exists that alcohols have any significant impact on canister efficiency or capacity. Thus no effects of alcohol fuels on deterioration are considered here.

In addition to the possibility of system deterioration for well-maintained vehicles, the effects of control system tampering and malmaintenance and defects (M&D) must also be considered. These are addressed separately below.

c. Tampering

Turning first to tampering, since many manufacturers are expected to use one of the liquid seal approaches to seal the fillpipe, the only other possible area for tampering involves the canister system and related feed and purge hoses. Given the similarity of these portions of onboard refueling and evaporative control systems, canister and hose system tampering for onboard systems was modeled using similar information from tampering surveys for evaporative control systems. The canister and hose system tampering rates used here are based on EPA in-use tampering surveys (I-A-40).

When analyzed using simple linear regression techniques, the canister and hose tampering rates for LDV's and LDT's can be modeled as presented below:

LDV's: $Tamp = -1.01 + 0.0736(M)$
LDT's/HDGV's: $Tamp = 1.20 + 0.0349(M)$
Tamp = Tampering incidence expressed in percent at a particular mileage (M)
M = Mileage/10,000

Absent any other information, the LDT tampering rate can be used to model HDGV tampering, since HDGV tampering data are not available in the surveys. This is due to the fact that HDGV evaporative emissions were uncontrolled prior to 1985.

Assuming average lifetime periods of 100,000 miles for LDV's, 120,000 miles for LDT's, and 110,000 miles for HDGV's, the average (midpoint) tampering rate for vehicles in each class would be 2.67, 3.29, and 3.12 percent, respectively. On a fleet-weighted basis this averages to about 2.8 percent.

For purposes of emissions modeling, it was assumed that tampering would completely disable the control system and the resultant control efficiency would be zero. This would happen if the canister were removed or if the feed or purge lines were cut completely. This is clearly conservative, since less severe forms of tampering would not reduce system efficiency as completely. The effect of this tampering on fleetwide emissions control was considered inherently in the modified MOBILE3 fuel consumption model runs performed to support the onboard analysis (I-B-37). The model considers, in addition to tampering, the effects of fleet turnover, scrappage rates, changing vehicle fuel economies, non-linear mileage accumulation rates, and all the other factors that affect the percentage of consumption. As can be seen in Table 2-3 in the portion of this document addressing phase-in of controls (Section 2.5), tampering reduces the in-use efficiency of onboard controls by about 3.8 percent over the long term. This is not the same as doubling the 2.8 percent mentioned above, primarily because more fuel is consumed early in the fleet life when tampering rates are low. Finally, it should be noted that these tampering rate effects may be substantially greater than actually occur, because placing the canister in the rear of the vehicle or in the underbody will reduce accessibility and therefore tampering incidences.

d. Malmaintenance/Defects

The final consideration with regard to onboard efficiency is related to the effects of malmaintenance and defects (M&D) on refueling emission control efficiency. The EPA has evaluated the rates of occurrence and evaporative emission effects of M&D as part of the in-use emission factors test program, and this is presently the best information available that can be used to estimate the impact on refueling emissions control. This analysis will be limited to M&D rates and effects on the fuel-injected vehicles tested, since the new motor vehicle fleet is expected to be almost 90 percent fuel-injected into the 1990's and beyond.

As shown in Table 2-2, the emission factor test program conducted by EPA has identified seven M&D types, their rates, and effects on emissions. Of these seven, two would have no effect on refueling emissions controls and a third would be very unlikely to occur in onboard equipped vehicles because a liquid/vapor separator will be used as part of the system. This leaves only four categories for further evaluation: purge system problems, purge hose disabled, canister filter dirty, and canister broken. As is shown below, these would have little effect on the fleetwide efficiency of onboard controls.

One hundred sixty-three fuel-injected vehicles were tested in the emission factors program. Of these 163, 12 had the M&D effects mentioned above. The remainder were problem-free for purposes of this analysis. Thus for commercial fuel, the effect is a 10.9 percent increase in emissions over the problem-free vehicles:

$$\frac{3\ (28.98) + 43.07 + 7\ (20.15) + 1(15.2) + 151(9.63)}{163} = 10.68 \text{ g/test}$$

Table 2-2. IN-USE EF TEST PROGRAM M&D TYPES, RATES OF OCCURRENCE, AND DIURNAL/HOT SOAK EMISSIONS FOR FUEL-INJECTED VEHICLES

Defect	No. of Vehicles	Rates* %	Avg. Evap. Emissions (g/test) Commercial (11.7 RVP)		
			DI	HS	Total
Gas Cap Leak	4	2.5	No effect on refueling emissions		
Air Cleaner Gasket Broken/ Missing	1	0.6	No effect on refueling emissions		
Canister Filter Dirty	7	4.3	14.49	5.66	20.15
Canister Saturated	2	1.2	Future problems fixed by liq/vap. sep.		
Canister Broken	1	0.6	2.14	13.06	15.2
Purge System Plugged/Damaged	3	1.8	18.50	10.48	28.98
Purge Hose Disabled	1	0.6	4.92	30.15	43.07
Problem-Free Emissions			7.56	2.07	9.63

*One hundred sixty-three fuel-injected vehicles tested.

$$\frac{10.68 \text{ g/test with M\&D vehicles}}{9.63 \text{ g/test problem-free}} = 1.109\text{: a 10.9\% increase in emissions}$$

The actual fleetwide increase could be less than 10.9 percent since this approach assumes all canisters have filters which require replacement. This is clearly not the case, since many manufacturers use closed bottom canisters.

Since the 97 percent onboard efficiency is considered a problem-free value, the increase in emissions shown above can be used to estimate the effect on refueling.

Refueling emissions after control: $5.9 \text{ g/gal } (1-0.97) = 0.177 \text{ g/gal}$

With a 10.9 percent increase, these emissions increase to 0.196 g/gallon. A 0.196 g/gallon emission rate for controlled vehicles is equivalent to an onboard efficiency of 96.7 percent instead of 97 percent; that is,

$$\text{Efficiency} = 1 - \frac{0.196}{5.9} = 0.967$$

This demonstrates that while M&D may affect emissions on some vehicles, the effect is negligible on a fleetwide basis.

e. Summary

In summary, it can be stated that onboard theoretical control efficiency (whether the 97 percent used here or the higher value demonstrated by others) may be reduced somewhat by in-use tampering effects. However, given the data currently available on canister deterioration and malmaintenance and defects, these effects are negligible overall.

2.3 EMISSION FACTOR FOR REFUELING LOSSES*

Comment: Several commenters felt that the refueling emission factors used in the July 1984 EPA analysis were too low and suggested alternative values.

One commenter stated that the AP-42 emission rate of 4.1 grams per gallon (g/gal) was too low, considering that RVP values for gasoline have been rising steadily for a number of years and that this would tend to increase the emission factor (I-H-21). Another commenter (BMW) felt that the emission factor of 5.0 to 5.5 g/gal developed by API was also too low, stating that the correct value was 7 g/gal for straight gasoline and even higher for alcohol blends. If a manufacturer designed a canister based on the 5 gram value, the canister might not be able to control the higher in-use emissions (I-H-2). Two auto industry commenters stated that the value of 4.54 g/gal used by the California Air Resources Board (CARB) was more representative than the AP-42 value (I-H-114, I-H-127).

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*1984 Federal Register topic.

Response: The EPA concurs with the comments that the AP-42 and API emission factors are both low, due largely to the fact that RVP values have increased considerably in recent years, as the Maryland Department of Health correctly pointed out. The EPA also agrees that the CARB value is too low as a nationwide value, for the same reason. Further investigations in this area uncovered a number of other literature sources on refueling emission rates. Some sources provided models (equations) for calculating refueling emission rates based on fuel RVP, dispensed fuel (T_D), and fuel tank temperatures (T_t). However, in most cases the models were developed using low RVP fuel and were not valid in the range of interest for dispensed and fuel tank temperature.

Since there were no usable published data or models available, EPA developed a formula for calculating refueling emission rates. This formula (discussed above in Section 2.1.4) is based on a multiple regression analysis of recent baseline test data for uncontrolled vehicles (I-A-69).

In order to calculate emission factors, further information on regional and national average values for the three main parameters that determine refueling emissions, i.e., dispensed temperature (T_D), tank temperature minus dispensed temperature ($T_t - T_D = T$), and RVP was necessary. Regional average values for these parameters were determined from available sources and were weighted according to regional fuel consumption in the U.S. in order to determine representative national average values. Using the emission factor formula and these data, EPA has calculated an average nationwide uncontrolled emission factor of 5.9 grams per gallon.* This emission factor will be used for all subsequent air quality and health exposure risk calculations.

In response to comments, BMW appears to confuse the emission factor described above with the emission rate that would be produced by the conditions specified in the draft refueling test procedure. The company is correct that the parameters found in the EPA test procedure, representing near worst-case conditions, would result in refueling emissions of approximately 7 grams per gallon. This value is representative of the canister design capacity necessary to enable manufacturers to meet the certification standard for refueling emissions. It would not be appropriate to specify average conditions for the refueling test procedure, since to do so would mean that the resulting systems would be inadequate to control refueling emissions in significant portions of the country during peak emission periods. The test procedure requirements were chosen so that additional system capacity would be provided (over that which would be required to control emissions in the range of 5.9 g/gal). This additional capacity would be needed to ensure that onboard systems are capable of controlling the majority of refueling emissions under some of the most adverse conditions likely to be found in the United States.

2.4 LEAD TIME

Comment: Several auto manufacturers and the California Air Resources Board (CARB) felt that 2 years lead time would be insufficient to implement onboard controls, and that from 3 to 6 years would actually be required. Some therefore felt that implementation by the 1988 model year was not feasible.

One manufacturer stated that 3 to 4 years lead time would be required due to system packaging problems and the "ripple effect," i.e., a redesign of other components in the system being necessitated whenever one component is changed (I-H-100). Two manufacturers stated that 4 years lead time would be necessary (I-H-2). One of these said the additional time would be required for development, repackaging the system, and for retooling all of the fuel tanks in the product line

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*Further discussion and information on how the refueling emission factor was calculated can be found in I-A-69.

(I-H-114). The other commenter stated that additional time would be required for development and testing of necessary components that do not currently exist (I-H-101). Another manufacturer stated that they would need 6 years lead time due to the necessity for large scale design changes and because of the difficulty of changing over all of their models simultaneously (I-H-22). CARB also felt that 4 years of lead time would be required, based on their experience with a fillpipe access rulemaking for Stage II (I-H-118). One manufacturer felt that 1989 would be the earliest possible model year for implementation (I-H-114). Another commenter stated that onboard controls could be implemented by the 1987 model year, since the technology involved is basically an extension of current evaporative emissions control systems (I-H-115). Petroleum industry interests who commented on the issue felt that 2 years was adequate lead time, since onboard technology already exists in current evaporative control systems (I-H-119, I-H-120).

Response: With the exception of the five auto manufacturers noted above, most manufacturers did not take exception to the 24 months lead time put forth in the July 1984 analysis. The EPA recognizes that the lead time requirements among the manufacturers may vary somewhat due to differences in areas such as product line design, testing capabilities, and the number of product offerings. However, as is discussed below, no strong arguments were presented against the 24-month lead time estimate.

As was discussed in the comments, onboard systems are in many ways similar to current evaporative emissions technology. With the exception of the fillpipe seal and fuel tank valve(s) (rollover, vent closure, fill limiter), no new technology is required and the design and implementation issues are similar to those faced in meeting the previous evaporative emission standards. In terms of currently available hardware, the components required are relatively uncomplicated and many of them need only to be sized up from current equipment. With regard to the two new components needed, three fillpipe seal approaches have already been demonstrated by EPA, API, and various auto manufacturers, and a number of different fuel tank valve designs have already been proposed by the auto industry and their suppliers (I-D-319, I-H-158). The EPA therefore does not believe that an extensive amount of system design and development work would be required to begin implementation of onboard controls.

Further, while EPA recognizes that some vehicle redesign may be necessary to accommodate refueling canisters on smaller vehicles, it does not appear that an extensive vehicle redesign program will be required overall. It should be noted that smaller vehicles generally have smaller fuel tanks and would thus require smaller refueling control canisters. Thus, the vehicle redesign burden may not be as great as portrayed in the comments.

Given these arguments, EPA believes a lead time period of 24 months is reasonable. All previous evaporative emission standards have been implemented with 24 months of lead time (both light- and heavy-duty) and, given the complexity and magnitude of the task, 24 months for implementing an onboard requirement appears reasonable.

The question of retooling was given consideration in the July 1984 EPA analysis. A period of up to 12 months was assumed, depending on whether current tooling must be modified or whether new tooling must be procured. The EPA did not consider retooling to be a critical path item, however, since it could be carried on in parallel to final in-vehicle testing of components and to certification. The 1984 analysis referred primarily to tooling for control system components such as fillpipe seals and fill-limiter valves, but there is no reason it could not also be applied to necessary fuel tank modifications or to minor vehicle modifications necessary for packaging the system. It should be noted that many routine tooling changes are accomplished in periods of far less than 12 months. For example, tooling changes accompanying model year changeover are accomplished in only a few months.

The longer lead time estimates provided by CARB and several other auto manufacturers appear to allow some accommodation for normal model change, retirement, and new model introduction. This is clearly the case in the Toyota and CARB comments (I-H-22, I-H-118), as evidenced by other materials provided by these commenters (I-D-263, I-F-78). The EPA expects similar considerations were included by the other commenters as well, since the wide range in lead time estimates received in the comments cannot be explained by differences in product design, testing capacity, etc. The CARB estimate was based on their experience in implementing the fillpipe access requirement for Stage II. As was stated previously, EPA does not expect that widespread vehicle redesign will be necessary as was required to comply with the California fillpipe access requirements. Therefore, EPA believes the lead time estimates of 4 to 6 years are unrealistically long.

One lead time item in the July 1984 analysis may merit further consideration in the future as more information becomes available. The EPA assumed that 10-12 months would be required for certification. This estimate may need to be re-examined in the future since manufacturers would be facing recertification of their entire product lines and may also need to conduct some vehicle safety crash testing to assure compliance with FMVSS 301. While it is not certain, some extension of lead time may be warranted in order to accommodate the concentrated recertification effort on the part of the industry. Alternatively, it may be desirable to phase in controls by vehicle class or by some other similar approach in order to distribute the certification burden over more than one model year.

It should be noted that the date of final rulemaking could also significantly affect the actual amount of lead time provided. Depending on the timing of the promulgation of the final rule, manufacturers may receive up to 11 months additional lead time over the 24 months that EPA suggested in the July 1984 analysis. Since the model year usually begins in September, publication of the FRM after that month would allow the manufacturers the remaining fraction of the model year of publication, plus two full model years thereafter. Manufacturers might, therefore, have considerably more than the 24-month minimum, depending on the timing of the rulemaking process.

As was alluded to above, the actual model year of implementation for an onboard requirement depends on when a final rule would be published. Given the time necessary for developing a final rule plus the minimum lead time, the earliest possible model year for an onboard requirement is probably 1990 (see Figure 2-10). The NRDC comment that onboard controls should be implemented by the 1987 model year appears to be based on NRDC's interpretation of the requirements of Section 172 of the Clean Air Act, rather than on a realistic assessment of the technological feasibility of implementing such a requirement by that date. However, EPA does not agree that Section 172 imposes any deadline

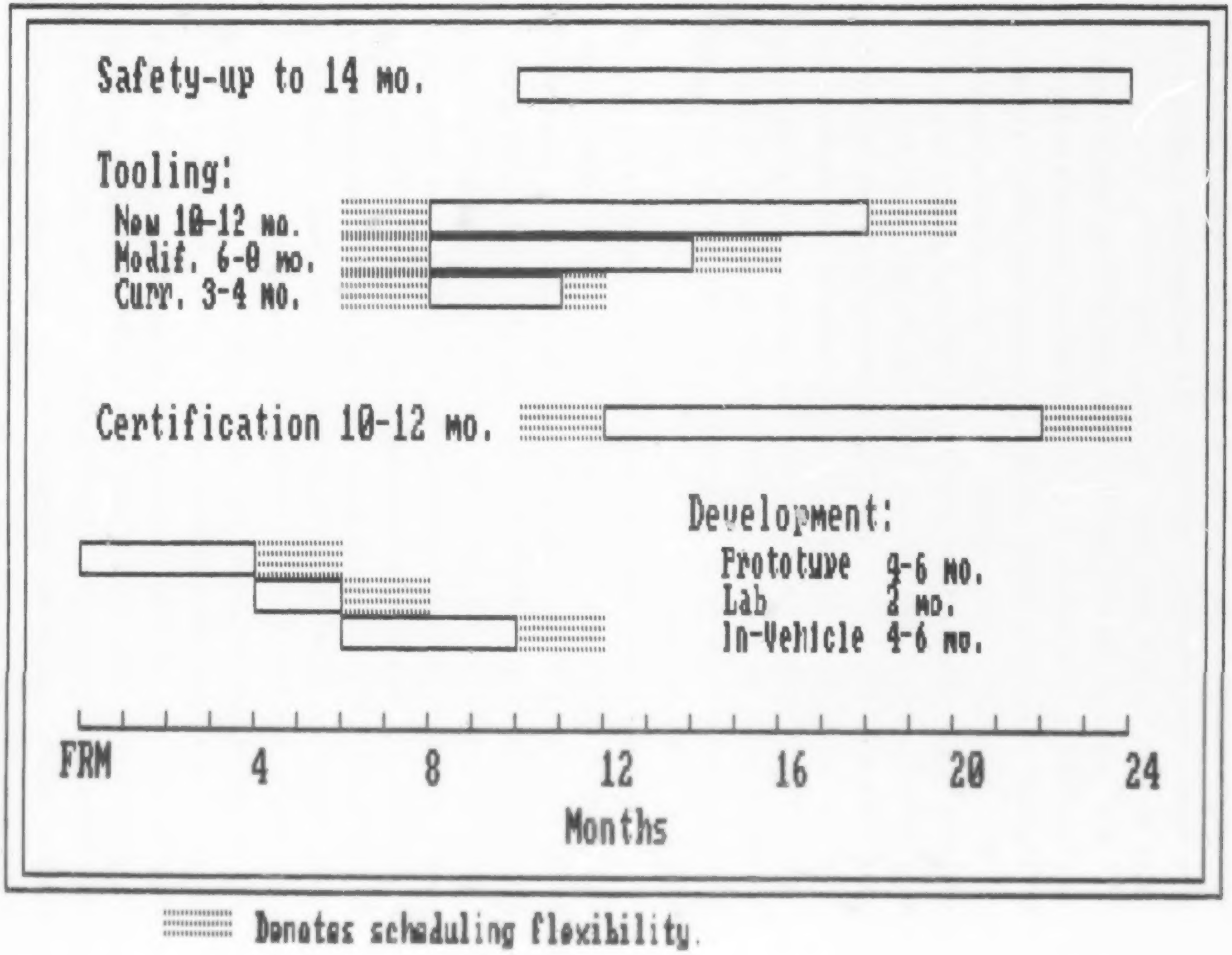

Figure 2-10. Onboard Leadtime

on the implementation of onboard controls under Section 202(a)(6) of the Act. Moreover, Section 202(a)(6) itself requires that any onboard regulation provide the industry adequate lead time.

In summary, EPA does not believe that the comments provided adequate basis to change the estimated lead time of 24 months. The EPA estimates that the 1990 model year would be the earliest practicable model year for implementation. As stated above, the industry might also be afforded some additional lead time beyond the 24 months estimated minimum, depending on when the final rule is promulgated. Thus, the exact amount of lead time available would depend on the timing of the final rulemaking. Nevertheless, EPA remains open on the leadtime issue and is willing to consider a phase-in or an increase in the amount of leadtime provided based upon information provided in response to the proposal.

2.5 PHASE-IN OF CONTROLS

Comment: Automotive industry and other commenters who favored Stage II pointed to the slower implementation of onboard controls (compared to Stage II) and stated that additional problems could cause the phase-in rate for onboard to be even slower than that stated in the July 1984 EPA analysis. Several commenters argued that onboard controls were less effective than Stage II because the full benefits of onboard would not occur until 10 to 14 years after implementation (I-H-22, I-H-93, I-H-99, I-H-100, I-H-101, I-H-104, I-H-114, I-H-115, I-H-117, I-H-118, I-H-124, I-H-127, I-H-128). One commenter felt that phase-in would be even slower due to tampering and the increasing age of the fleet (I-H-57). Another felt that implementation of onboard controls would result in an unwarranted delay in the control of refueling emissions (I-H-74).

Conversely, petroleum marketers and others who favored onboard controls generally felt that EPA had been too conservative in estimating the rate of onboard phase-in, stating that Stage II programs have their own implementation problems and might not be phased in any more quickly than onboard controls. Two commenters stated that the accelerated lead phasedown rule would virtually eliminate fillpipe tampering, which in turn would speed the phase-in of onboard controls due to higher in-use efficiency. They further stated that EPA had overestimated the fuel economy of future vehicles. Since the amount of control varies inversely with fuel economy, lower, more realistic fuel economy figures would result in more gasoline consumption subject to control (I-H-108, I-H-119, I-H-120). Some commenters also felt that problems in developing State and local standards and shortages of equipment and contractor expertise would delay the implementation of nationwide Stage II controls, possibly to as long as 7 years (I-H-94, I-H-99, I-H-102, I-H-108, I-H-109, I-H-119, I-H-120, I-H-124).

Response: The comments on the phase-in of refueling controls can be separated into two areas: (1) Stage II phase-in rate versus onboard phase-in rate and (2) assumptions for determining the phase-in rate for each control technology.

In general, EPA concurs with the commenters who claimed that Stage II could be implemented more quickly than onboard. It is estimated that, under optimum conditions, Stage II could be implemented fully in about 3 years. In response to comments on the lack of availability of this equipment, the Agency contacted Stage II equipment manufacturers, who indicated that meeting the expected demand could be a done (I-E-10, I-E-11, I-E-12). However, given the need for enabling legislation in some cases, plus the potential for some shortages of trained installers and needed equipment, it is very possible that Stage II implementation could take considerably longer than 3 years. Thus, a period of 7 years was considered as a longer time estimate (3 years for non-independents, 7 years for independents) for nationwide strategies and 5-1/2 years for nonattainment area strategies for both independents and non-independents. An analysis conducted by Radian Corporation under contract to API supports the implementation range presented above (I-H-151).

Since the phase-in of onboard controls is a function of fleet turnover, the period to achieve full implementation is longer than Stage II. In an effort to better evaluate the phase-in rate of onboard, EPA has developed a new, more sophisticated highway fuel consumption model that incorporates updated fuel economy, sales, and scrappage rate data. This new model, based on EPA's MOBILE3 emissions model, provides a more accurate estimate of the rate of increase of controlled consumption than was provided by the less sophisticated model used in the July 1984 EPA analysis (I-A-99, I-B-37). As shown in Table 2-3, the new model indicates that control of 50 percent of total highway gasoline consumption would be achieved within 5 years of implementation and that more than 75 percent control would be achieved within 10 years. These results are similar to those originally projected in the July 1984 analysis.

The new analysis assumes no fillpipe tampering for two reasons. First, many manufacturers are likely to utilize the tamper-proof liquid seals. Second, for those onboard systems that do employ mechanical seals, the economic incentive for fillneck tampering has decreased substantially as a result of the decrease in the unleaded/leaded price differential. This leaves disablement of the canister system as the only possible form of tampering. Canister system tampering includes tampering with the canister as well as all valves and vapor hoses related to the load and purge functions of the system. Canister system tampering rates of 2.67 percent and 3.29 percent, respectively, were assumed for LDV's and LDT's, based on the 1982 through 1985 NEIC Tampering Surveys (I-A-40). These replace the composite tampering rates used for the calculations in the 1984 analysis.

Details on the fuel economy, scrappage rates, dieselization rates, and other values used in the model are shown in documents contained in the public docket (I-A-99, I-B-37). While the accuracy of any projection which is carried many years into the future, such as these are, is problematic, the impact of any errors on the onboard phase-in rate is not significant. For example, EPA considered a scenario where fuel economies were 10 percent worse than projected in the model, yet this had no effect on the phase-in rate (I-B-21). The primary reason that the model is not sensitive to small errors in the projected values is that both the controlled and total consumption are affected about equally. Thus, the controlled fraction is affected only a small amount.

Given this information on the revised analytical approach for determining onboard and Stage II phase-in rates, the phase-in rates and effectiveness for Stage II and onboard controls can now be compared. For onboard, the phase-in rate is the same for a nationwide

Table 2-3. PHASE-IN OF ONBOARD REFUELING CONTROLS

Year	Annual Consumption, 10^9 gal	Tampered Consumption, 10^9 gal	Controlled Consumption, 10^9 gal	Potential Fraction Controlled	Actual Fraction Controlled
1989	81.009	0.000	0.000	0	0
1990	79.901	0.062	9.749	0.122789	0.122013
1991	78.797	0.180	18.276	0.234222	0.231938
1992	77.686	0.344	25.741	0.335775	0.331347
1993	76.575	0.537	32.202	0.427542	0.420529
1994	75.498	0.742	37.781	0.510252	0.500424
1995	74.384	0.952	42.502	0.584185	0.571386
1996	73.425	1.163	46.617	0.650732	0.634893
1997	72.641	1.368	50.220	0.710177	0.691345
1998	71.986	1.563	53.389	0.763371	0.741658
1999	71.442	1.747	56.113	0.809888	0.785434
2000	71.023	1.914	58.465	0.850133	0.823184
2001	70.996	2.063	60.715	0.884247	0.855189
2002	70.998	2.197	62.647	0.913322	0.882377
2003	71.048	2.311	64.226	0.936508	0.903980
2004	71.089	2.405	65.508	0.955324	0.921493
2005	71.151	2.481	66.490	0.969361	0.934491
2006	71.205	2.534	67.187	0.979159	0.943571
2007	71.247	2.576	67.736	0.986877	0.950721
2008	71.301	2.609	68.136	0.992202	0.955611
2009	71.346	2.633	68.429	0.996019	0.959115
2010	71.395	2.650	68.642	0.998557	0.961440
2011	71.439	2.660	68.757	0.999692	0.962457
2012	71.481	2.662	68.802	0.999762	0.962522
2013	71.521	2.665	68.844	0.99832	0.962570
2014	71.561	2.666	68.884	0.999846	0.962591
2015	71.598	2.667	68.922	0.999874	0.962625
2016	71.663	2.669	68.959	0.999512	0.962268
2017	71.668	2.669	68.995	0.999665	0.962434
2018	71.701	2.669	69.030	0.999972	0.962748
2019	71.735	2.669	69.066	0.999986	0.962780
2020	71.768	2.669	69.099	1	0.962810

or nonattainment area program. For Stage II, the implementation schedule is different for nationwide and nonattainment area programs. Also, it should be noted that the Stage II analysis allows exemption for nonindependent stations with a throughput less than 10,000 gallons per month and independent stations with a throughput of less than 50,000 gallons per month.

Table 2-4 provides a comparison of control effectiveness for onboard and Stage II in both nationwide and nonattainment areas. For onboard, the control effectiveness rates shown in Table 2-3 were used. For Stage II, the implementation periods discussed above were used, together with the implementation rate from the draft Regulatory Impacts Analysis (RIA) Vol. I. A control efficiency range of 62-86 percent was used for Stage II.

Table 2-4 shows that for a nationwide program, Stage II has no long-term advantage over onboard. For the more optimistic phase-in schedule and higher in-use Stage II efficiency, Stage II has a higher control effectiveness than onboard until the eighth year. At that point, the lower efficiency of Stage II and the exemptions assumed yield less reductions than onboard. For the longer Stage II phase-in and lower in-use efficiency, onboard is always better.

For a nonattainment area program, 3-year and 5-1/2-year phase-in schedules were used for Stage II. For the higher Stage II efficiency, Stage II clearly has a short-term advantage. Onboard achieves greater reductions in the eighth year. However, for the lower Stage II efficiency, onboard will achieve greater reductions from the outset. For a longer implementation period in nonattainment areas, Stage II has no short-term benefit over onboard.

Thus, while Stage II controls could be implemented more quickly than the motor vehicle fleet could be equipped with onboard controls, it is not clear that this provides any meaningful long-term advantage. Onboard control effectiveness reaches the most optimistic Stage II values about 4 years after Stage II and from that point, the reductions from onboard surpass Stage II. Onboard eventually captures about 93 percent of all refueling vapors, while Stage II captures only 48-66 percent, including some emptying losses. Thus, in the long-term, the onboard strategy has the advantage.

Table 2-4. COMPARISON OF PHASE-IN CONTROL EFFECTIVENESS (% OF AVAILABLE REDUCTION)

		Nationwide Stage II[b]		61 NA Area Stage II[b]	
Years	Onboard[a]	3 yrs/86%	7 yrs/62%	3 yrs/86%	5-1/2 yrs/62%
1	12%	15%	7%	28%	5%
2	22	45	20	55	13
3	32	62	34	63	22
4	41	64	41	65	30
5	49	64	43	66	39
6	55	64	44	66	46
7	62	64	46	66	47
8	67	64	46	66	48
9	72	64	46	66	48
10	76	64	46	66	48

[a] Controlled consumption from Table 2-3 x 97% theoretical efficiency.

[b] Assumes a 10/50 exemption level and a linear phase-in rate.

2.6 COST OF ONBOARD CONTROLS*

Comment: Many of the comments addressed the costs of onboard control systems. The comments on cost can be broadly grouped into two categories. The first category consists of those comments claiming that the cost range estimated by EPA ($15-$25) adequately represents the cost of control. Most of the commenters in this group have a direct interest in the gasoline marketing industry (e.g., service station owners, oil companies). The second category consists of those comments that claimed that the EPA estimate was low and should be modified upward. Most of these commenters are automobile manufacturers or are representing areas of the country where Stage II controls are already in place.

The comments that generally agreed with the EPA cost estimate varied widely in terms of complexity and detail. The large majority of these commenters simply claimed that the onboard system cost would fall within or below the range proposed by EPA and gave little supporting evidence. The cost estimates that were given ranged from $9 (I-H-1) to $17 (I-H-120). The comments submitted by the American Petroleum Institute (API) (I-H-120) were the most detailed of those in this group, and the API work is referenced in many of the other comments. The API comments referred to the cost of refueling emission control systems assembled and tested on vehicles during their 1978 demonstration program. A comparison of the cost estimates made by EPA, API, and L.H. Lindgren is also presented as part of the API comment package. This cost comparison generally supports the EPA estimates.

The comments that disagreed with the EPA cost estimate also varied widely in complexity and detail. The Ford Motor Company comment (I-H-114) addressed the issue of the cost of onboard control in more detail than did any other comment. In their comments, Ford proposed a refueling control system which they believed would function adequately under all in-use conditions and attempted to give a detailed estimate of costs involved in equipping their cars and trucks with such a control system. Ford's weighted average cost to the consumer for onboard control is $53 per vehicle.

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*1984 Federal Register topic.

The comments submitted by General Motors (I-H-117) also included a relatively well supported estimate of the costs of control. GM provides a component-by-component cost comparison as well as an overall per-vehicle cost to the consumer. GM estimates the consumer cost of control to be at least $30. This is the lowest estimate submitted by an auto manufacturer.

Chrysler Corporation included a very detailed description of a prototype onboard control system in their comments (I-H-101). The function of each component in the system and of the system in general is clearly outlined in the Chrysler document. Chrysler also gave an estimated per-vehicle cost of control - $85. Chrysler did not attempt to provide a component-by-component breakdown of this cost, however, and it is thus very difficult to assess the appropriateness of this estimate.

Seven automobile manufacturers, other than the three referred to above, submitted comments which included an estimate of the per-vehicle consumer cost of onboard control of refueling emissions. None of these commenters, however, supplied a detailed derivation of its cost estimate. Therefore, the commenters and their respective cost estimates are simply listed below:

Commenter	Cost ($/Vehicle)
American Honda Motor Company (I-H-104)	≤90
American Motors Corporation (I-H-128)	≤50
BMW of North America (I-H-2)	65
Mazda (North America) (I-H-53)	60-75
Toyota Technical Center, USA (I-H-22)	70-100
Volkswagen of America (I-H-116)	72
Volvo-North American Car Operations (I-H-100)	60

Within the general area of control system costs, certain issues are noteworthy because they were raised by more than a single commenter. One comment frequently made was that EPA should have included the cost of a device or devices to provide fill-limiting capabilities and rollover protection. The comments noted that the cost of the system described in the July 1984 analysis did not include any provisions for these requirements.

Several commenters claimed that adding onboard control systems to vehicles could negatively impact the performance of exhaust emission control systems. They went on to assert that there would be costs associated with recalibration or other changes needed to insure that onboard equipped vehicles would comply with exhaust emission standards. The cost estimate in the 1984 EPA analysis did not include any cost directly associated with exhaust emission compliance.

Several commenters also discussed the refueling test procedure. Commenters pointed out that at the time of the publication of the July 1984 analysis, EPA had not proposed any test procedures or emission standards to be used in determination of compliance with an onboard regulation. These commenters claimed that without this information on test procedures and standards, it is difficult for them to accurately assess the complexity of the system that would be needed to control refueling emissions. Because of the uncertainty in system designs, they claim it is very difficult to estimate system costs. One auto manufacturer made the related comment that onboard system costs would be heavily influenced by the values chosen for the critical test procedure parameters such as fuel temperature and volatility (I-H-127).

Costs associated with ensuring the safety of onboard systems using a mechanical fillneck seal was another area of frequent comment. Commenters noted that overpressurization of a fuel tank during a refueling event (caused by a fueling nozzle malfunction) could lead to fuel being forced from the fillneck during or after the refueling event. This could result in fuel squirting onto the nozzle operator or onto the ground. The commenters claimed that a pressure relief device would be needed to avoid these safety concerns. They went on to point out that no such component was included in EPA's original onboard cost estimate.

In addition to the areas of comment listed above, some important cost issues were raised by only one or a few commenters. These included costs for: (1) onboard system maintenance, (2) taxes and insurance, and (3) enforcement of an onboard regulation.

One final area that was frequently raised in the comments was the magnitude of the factor used by EPA to mark system costs at the vendor level up to the Retail Price Equivalent (RPE), or cost to the consumer.

Because this issue was raised quite frequently, the comments on the markup factor will be addressed separately from the other cost-related comments.

Response: The EPA has examined and evaluated all of the comments related to the cost of onboard control of refueling emissions and has developed a revised cost estimate based on this evaluation. The most thorough and well documented comments on cost were submitted by commenters claiming that the original EPA cost estimate was too low. As was discussed in the technological feasibility section of this document, these comments, in combination with the results of EPA testing of refueling vapor control systems at the Motor Vehicle Emissions Laboratory, have convinced EPA that the refueling control system described in the July 1984 EPA analysis could be improved in many ways.

The technological feasibility section of this study (Section 2.1.3) contains a description of an onboard control system that was designed as an improvement to the system described in the July 1984 analysis. The improvements in the system responsd to comments received on the cost and feasibility of onboard control systems. The remainder of the response to comments on onboard system cost (excluding comments on markup factors which are discussed separately) is a detailed breakdown of the cost of the system described in the technological feasibility section of this chapter. First, the system costs are given for three vehicle categories (LDV's, single and dual tank LDT's) along with a breakdown of component cost estimates. Then, for each cost component, the source of the cost estimate is given, along with a description of any calculations used in arriving at the estimate. Finally, if available, alternate cost estimates are quoted and evaluated.

2.6.1. Onboard Control System Costs

Table 2-5 summarizes the calculation of the onboard control cost estimates for light-duty vehicles (LDV's), light-duty trucks (LDT's), and light-duty trucks with dual fuel tanks. For each vehicle category, the values of cost components for both integrated and separate systems are presented. Two long-term costs of onboard control are also presented at the bottom of Table 2-5. The 1994 cost estimate reflects three differences from the 1989 cost estimate: (1) the absence

Table 2-5. ONBOARD CONTROL SYSTEM COSTS

	LDV		LDT		DUAL	
	Integrated	Separate	Integrated	Separate	Integrated	Separate
Activated Carbon	2.20	2.20	2.94	2.94	5.88	5.88
Canister Body	2.24	3.21	2.84	3.84	6.67	7.85
Vapor Vent Valve	4.60	4.60	4.60	4.60	9.20	9.20
Vapor Line	1.44	2.40	1.44	2.40	5.12	5.76
Fill Limiter	0.82	0.82	0.82	0.82	1.64	1.64
Liquid/Vapor Separator	0.73	0.73	0.73	0.73	1.46	1.46
Fillneck Extension	1.21	1.21	1.21	1.21	2.42	2.42
ECU/Purge Modifications	0.07	0.22	0.07	0.22	0.14	0.44
Tank Modifications	0.50	0.50	0.50	0.50	1.00	1.00
Packaging	0.50	0.50	0.50	0.50	0.50	0.50
Assembly	---	0.75	---	0.75	0.75	1.50
Certification	0.61	0.61	0.77	0.77	0.77	0.77
Facilities Modifications	0.30	0.30	0.30	0.30	0.30	0.30
Vendor Cost	15.22	18.05	16.72	19.58	35.85	38.72
Markup by 1.26	19.18	22.74	21.07	24.67	45.17	48.79
Systems Engineering	0.45	0.45	0.69	0.69	0.69	0.69
Engineering LDT - Dual					0.25	0.25
Total R.P.E. Cost	19.63	23.19	21.76	25.36	46.11	49.73
1989	20.00		22.20		46.60	
1994	17.70		19.60		42.70	
2000	16.30		18.10		40.50	

of modification costs, which would drop out as vehicle designs incorporate onboard controls and previous costs are amortized, (2) the absence of certification and systems engineering costs after these costs have been amortized, and (3) improvements in fuel economy. The cost for the year 2000 represents the cost of control after a number of the first vehicles with onboard control have left the fleet and reflects further improvements in fuel economy and the absence of facilities modification costs. The onboard cost items in Table 2-5 are discussed below.

The hardware costs shown in Table 2-5 can be characterized as EPA's best estimate at this time. To be conservative, the higher end of the cost ranges were used when a range was given for a component.

a. Activated Carbon

One of the vital functions of an onboard control system is the collection and storage of hydrocarbon vapors displaced during a refueling event. The first item in Table 2-5, activated carbon, is used as the hydrocarbon storage medium for current evaporative emission control systems.

The activated carbon used in the onboard control system tests at MVEL was Westvaco extruded activated carbon. This type of carbon was chosen because it has a relatively low cost, a high working capacity, and provides a low backpressure during adsorption.* The cost estimates shown in Table 2-5 are based on the characteristics of this carbon and include capacity for refueling vapors only. The specifications for this carbon are shown below:

Carbon base	Wood
Butane working capacity	105 g/liter C
Apparent density	300 g/liter = 0.661 lb/liter
High volume cost to vehicle manufacturer	$1.40/lb

The cost and working capacity figures were quoted by Westvaco representatives. The apparent density figure is a compromise between the density quoted by Westvaco (320-340 g/liter) and the apparent density as measured at MVEL (260 g/liter, loosely packed). It should be noted that each of these figures will vary with the carbon base, mesh size, and manufacturer chosen.

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*This is not meant as an endorsement of this product or its manufacturer.

Ford Motor Company asserted that the cost of activated carbon was \$2.00 per pound. Ford may be using a more dense product (more working capacity per pound of product) or a more expensive product. Other carbons have been quoted at only \$1.00 per pound. Since EPA has been given a quote of \$1.40/lb for a carbon that appears to function adequately, this cost has been used in this cost estimate (I-B-27).

The first step in finding appropriate carbon bed sizes for various fuel tank sizes was to develop a refueling emission rate. This rate, when multiplied by an appropriate fuel tank size, gives the total mass of hydrocarbon that is expected to be displaced from a typical fuel tank during the refueling capacity portion of EPA's proposed test procedure. The emission rate used by EPA was found using a regression equation generated from a series of over 100 uncontrolled refueling tests done on a number of vehicles. The uncontrolled test program and the development of the regression equation are fully discussed in an EPA technical report entitled "Refueling Emissions from Uncontrolled Vehicles" (I-A-69). When the refueling test procedure conditions (dispensed temperature = 88°F, ΔT = 5°F, 11.5 psi RVP fuel) are evaluated in the regression equation, the emission rate it provides is 7.0 g/gal of fuel dispensed. In other words, the equation predicts that for each gallon of 11.5 psi fuel dispensed at the conditions specified in the proposed refueling test procedure, approximately 7.0 grams of hydrocarbon vapor would be displaced. (At 9.0 psi RVP the emission rate is 5.8 grams per gallon.)

The emission rate described above is used in combination with the gasoline working capacity of the chosen carbon to find necessary carbon bed size. The working capacity quoted above is a virgin butane working capacity and thus reflects neither carbon aging nor the difference between adsorption characteristics of butane gas and gasoline vapor. The working capacity for aged carbon is approximately 60 percent of the virgin working capacity. This figure was supplied by a manufacturer of activated carbon. In this analysis, the virgin working capacity was reduced by 50 percent to reflect aging and a moderate (10 percent) factor of safety. Gasoline vapor working capacities are generally estimated as some fraction of butane working capacities. The fractions quoted, depending on the source range from 60-85 percent (I-A-74, I-B-27). Sixty percent was used in this analysis in the interest of being conservative. Using the two fraction discussed above, the gasoline working capacity for aged carbon was calculated as shown below:

$$105 \text{ g/liter} \times 0.50 \times 0.60 = 31.5 \text{ liter}$$

The amount of carbon needed to control the vapor associated with each gallon of fuel dispensed was then estimated by dividing the emission rate (7.0 g/gal) by the aged, gasoline working capacity:

$$\frac{7.0 \text{ g/gal}}{31.5 \text{ g HC/liter C}} = \frac{0.222 \text{ liter C}}{\text{gal}}$$

The cost of this amount of carbon was found using the apparent density and price per pound for this carbon:

$$(0.22 \text{ liter C/gal}) \times (0.66 \text{ lb C/liter C}) \times \$1.40/\text{lb} = \$0.20/\text{gal}.$$

Per-vehicle carbon costs were estimated using average LDV and LDT fuel tank sizes. Fuel tank sizes were calculated by assuming a single tank driving range of 300 miles and dividing by fuel economy estimates for the years 1989, 1994, and 2000. These fuel economy estimates were taken from EPA's MOBILE3 fuel consumption model (I-A-99, I-B-37). Table 2-6 shows the calculation of activated carbon cost for LDV's and LDT's for 1989, 1994, and 2000. Because the test procedure requires only a 90 percent fill, nominal fuel tank capacities were multiplied by 0.9.

The comments submitted by Ford indicate a higher carbon cost than that developed by EPA. Ford Motor Company uses a lower working capacity (6.7 g HC/100 mg carbon vs. 10.5 g HC/100 g carbon), a lower refueling emission factor (5.2 g HC/gal vs. 7.0 g HC/gal) and a higher carbon cost ($2.00/lb vs. $1.40/lb.) than does EPA. The difference in the working capacities could be due to the use of a different carbon, or to a different approach to calculating working capacity, or a combination of both. Ford also uses a larger fuel tank capacity (20 gal) than does EPA (LDV-12.2, LDT-16.3).

The methodology used in this analysis to estimate the size of the canister needed for onboard control systems is somewhat irregular in that it was assumed that the activated carbon needed for refueling emission control would be added to the existing evaporative control capacity. The canister sizing was done very early in the analysis process when EPA had little information with which to estimate necessary carbon bed volumes, and the additive methodology was used to ensure that an ample carbon volume was used.

Since the time when the carbon bed volumes were estimated, EPA has collected more information on carbon canisters. This information, which was presented to industry representatives at an April 10, 1986 workshop, has some implications on the canister sizing question, and clearly shows that a tradeoff exists between the air flow rate used to purge the canister and the effective working capacity of a given canister. The EPA used the information on the purge response characteristics of several activated carbon canisters to estimate the range of canister size needed for control of refueling and evaporative emissions. The canister sizes developed previously by EPA (Table 2-6) fell within this range.

b. Canister Body

Having estimated carbon bed sizes, it is now possible to develop costs for carbon canister shells. The cost estimates made in this analysis are based on work done for API and MVMA by Leroy H. Lindgren in 1983 (I-D-269). Lindgren began this work for API in 1983 and revised it under contract to MVMA in 1984 (the work for MVMA was included in their comment package (I-H-127)). In the 1983 study, Lindgren estimates the manufacturing cost of an 850 ml evaporative canister. In this study it is assumed that Lindgren has accurately estimated the cost of an 850 ml canister shell and that the cost of larger canisters can be found by scaling the costs by the ratio of the canister surface areas.

In order to simplify this analysis, it was assumed that all canisters are cylindrical in shape with equal dimensions of height and diameter. Using this assumption, it was possible to calculate a surface area for any canister volume, using only the formulas for the volume and surface area of a cylinder with closed ends:

$$V = \pi r^2 h = \pi \frac{d^3}{4} \quad (d=h) \qquad \text{(volume)}$$

$$A_s = 2\pi r^2 + \pi dh = \pi d^2 + \frac{dh}{2} = (1.5)\pi d^2 \quad \text{(surface area)}$$

Table 2-6. CALCULATION OF CARBON BED VOLUME AND COST

Calculation Parameter	LDV 1989	LDV 1994	LDV 2000	LDT* 1989	LDT* 1994	LDT* 2000
Driving Range (mi)	300	300	300	300	300	300
Fuel Economy (mi/gal)	24.61	26.64	29.13	18.43	18.99	20.56
Fuel Tank Capacity (gal)	12.2	11.3	10.3	16.3	15.8	14.6
90% Fill (gal)	11.0	10.1	9.3	14.7	14.2	13.1
Carbon Bed Volume (ml)	2,440	2,240	2,060	3,260	3,150	2,900
Carbon Cost ($)	2.20	2.02	1.86	2.94	2.84	2.62

*The capacity and cost of carbon needed to control refueling emissions for LDT's with dual fuel tanks was estimated by doubling the LDT values.

The volume formula was used to solve for the diameter of the canister (equal to the height according to the assumption discussed above). The area formula is shown to demonstrate that the ratio of two surface areas is equal to the ratio of the square of their diameters, or equivalently their radii:

$$\frac{1.5\,\pi\,d^2}{1.5\,\pi\,d'^2} = \frac{d^2}{d'^2} = \frac{r^2}{r'^2}$$

In the Lindgren cost analysis, the vendor selling price of the canister shell can be broken down into three parts; component costs, assembly costs, and overhead and profit markups. In scaling the cost of the 850 ml canister, the component cost is the portion of the vendor cost that was scaled by the ratio of the surface areas. The EPA does not expect the cost associated with assembling a large canister to be any different from that associated with assembling a smaller canister and has accordingly applied an assembly charge of $0.24 to the component cost of each canister. Finally, because the markup factor used here is multiplicative, the change in canister costs associated with the difference in canister size will be magnified by the vendor markup factor of 1.4.

A final complication in the estimation of the canister cost is that a vehicle with an integrated evaporative/refueling system will replace the smaller evaporative emission control canister(s) with a single larger canister to control both evaporative and refueling emissions. The removal of the evaporative canister implies a lower overall cost, since the cost for an integrated evaporative/refueling canister would be less than the cost of two smaller separate canisters whose combined volume equaled that of the integrated canister.

In order to calculate the value of this credit, evaporative emission control canister sizes must be evaluated for each vehicle class of interest. In this analysis, it has been assumed that light-duty vehicles and light-duty trucks currently use an evaporative emission control canister of 850 milliliters, and light-duty trucks with dual fuel tanks use a single canister of 1,500 milliliters volume. Although these canister sizes may be smaller than the average evaporative canisters in use today, the use of a small canister leads to a more conservative estimate of the onboard system cost. This is because the smaller evaporative canister size leads to a lower value for the credit. This is offset somewhat by the fact that the cost of the integrated canister shell would be marginally less with a smaller evaporative capacity (see Table 2-7). Therefore, the assumption of small evaporative canister sizes is reasonable.

The calculation of canister shell costs is detailed in Table 2-7. In general, there were 6 steps used in the calculation of canister shell costs. First, the calculated refueling capacity was added to the assumed evaporative canister capacity to give a total onboard canister capacity. Then, the square of the radius of a cylinder of the appropriate volume was calculated. The ratio of this squared radius to that of the 850 ml canister costed by Lindgren (26.35 cm^2) was then used to scale the component cost of the 850 ml canister to the appropriate amount. To this calculated component cost, \$0.24 was added for assembly to give a total manufacturing cost. Next, the manufacturing cost was multiplied by 1.4 to account for overhead and profit at the vendor level. Finally the total vendor selling price was multiplied by 1.03 to express the cost in terms of 1984 dollars. Although the calculation of the canister shell cost for separate systems is somewhat different, the detailed calculations in Table 2-7 should adequately demonstrate the differences. Table 2-8 shows the canister costs for each system evaluated in this analysis.

Ford Motor Company and General Motors were the only two commenters that gave estimates of total canister costs (including carbon). Ford estimated the total canister costs to be about \$7.50 per vehicle (LDV and single tank LDT) assuming a refueling emission factor of 5.2 grams per gallon. General Motors estimated the canister costs for a typical passenger car to be \$5.81. The EPA's estimated average canister costs are \$4.56 and \$5.90 for light-duty vehicles and single tank light-duty trucks, respectively. Ford's canister costs are higher than EPA's for several reasons. Much of the difference can be attributed to the fact that Ford assumed a fuel tank size of 20 gallons. The EPA calculated average fuel tank sizes of 12.2 and 16.3 gallons for LDV's and single tank LDT's, respectively, based on an assumption of a 300-mile driving range. The Ford estimate is almost 65 percent larger than the LDV estimate, and over 20 percent larger than the LDT estimate. Although EPA has received some information suggesting that some manufacturers

Table 2-7. CALCULATION OF CANISTER SHELL COSTS

Integrated Systems

Vehicle Class	Calculated Refueling Capacity (ml)	Assumed Evap Volume (ml)	Onboard Canister Required (ml)
LDV	2,440	850	3,290
LDT (Single)	3,260	850	4,110
LDT (Dual)	6,520	1,500	3,260 + 4,760

Typical calculation of canister shell cost:

- Onboard Canister Cost

  - Solve for square of radius from necessary onboard volume.

    $$3{,}290 \text{ cc} = r^2 \pi h = 2 \pi r^3$$
    $$r = 8.06 \text{ cm}$$
    $$r^2 = 64.96$$

    Scale component cost by ratio of square of radii - 850 ml canister $r^2 = 26.35$, component cost = \$1.06

    $$\text{Component cost} = \$1.06\ (64.96/26.35) = \$1.06\ (2.47) = \$2.61$$

  - Add in assembly cost \$0.24
    \$2.61 + \$0.24 = 2.85

  - Markup by factor of 1.4
    \$2.85 (1.4) = \$3.99

- Subtract cost of 850 ml evaporative canister (\$1.82)
  \$3.99 - \$1.82 = \$2.17

- Convert to 1984 dollars - multiply by 1.03*
  \$2.17 (1.0291) = \$2.24

---

*Average new car CPI for 1984 (208.5) divided by average for 1983 (202.6).

Table 2-7. CALCULATION OF CANISTER SHELL COSTS
(concluded)

Separate Systems

Vehicle Class	Calculated Refueling Capacity (ml)	Assumed Evap Volume (ml)	Onboard Canister Required (ml)
LDV	2,440	850	2,685 + 425
LDT (Single)	3,260	850	3,685 + 425
LDT (Dual)	6,520	2,500	4,010 + 4,010 + 1,000

Typical canister shell cost calculation:

- o Onboard canister costs

$2{,}865 \text{ ml} = \pi r^2 h = 2\pi r^3$ $\quad r = 7.70$ $\quad r^2 = 57.24$

$425 \text{ ml} = 2\pi r^3$ $\quad r = 8.3$ $\quad r^2 = 16.60$

- Scale component costs by ratio of square of radii - 850 ml canister $r^2 = 26.35$, component cost = \$1.06.

Component Cost = \$1.06 (59.24/26.35) = \$1.06 (2.25) = \$2.38

= \$1.06 (16.60/26.35) = \$1.06 (0.63) = \$0.67

- Add in assembly cost of \$0.24

\$2.38 + \$0.24 = \$2.62 \$0.67 + \$0.24 = \$0.91

- Mark up by factor of 1.4

\$2.62(1.4) = \$3.67 \$0.91(1.4) = \$1.27

- Total canister costs

\$3.67 + \$1.27 = \$4.94

- o Subtract cost of 850 ml evaporative canister (\$1.82)

\$4.94 - \$1.82 = \$3.12

- o Convert to 1984 dollars - multiply by 1.0291

\$3.12(1.0291) = \$3.21.

Table 2-8. SUMMARY OF CANISTER SHELL COSTS
($/vehicle)

	Year		
	1989	1994	2000
Integrated Systems			
LDV	2.24	2.08	1.94
LDT (single)	2.84	2.76	2.58
LDT (dual)	6.67	6.43	6.07
Separate Systems			
LDV	3.21	3.05	2.90
LDT (single)	3.84	3.76	3.57
LDT (dual)	7.85	7.69	7.33

may not reduce fuel tank sizes as vehicle fuel economy improves in the future as EPA expected, 20 gallons clearly does not represent a fleet-wide average tank size. The remaining difference between the EPA and Ford canister cost estimates is due to differences in carbon prices ($1.40 vs. $2.00 per pound) and working capacities (6.7 g HC/100 g vs. 10.5 g HC/100 g).

There is insufficient detail in the General Motors comment to attempt to explain the difference between the GM and EPA estimates. However, it is expected that the carbon canister costs differ for reasons such as those discussed above for Ford.

As stated earlier, EPA has observed a tradeoff between working capacity and purge rate that could not be quantified because of the many design variables involved. Any upward adjustment in the EPA estimates of carbon volume as a result of this tradeoff could bring the EPA cost somewhat nearer to the General Motors and Ford estimates.

c. Refueling Vent Line Valve

The next component examined is the refueling vent line mechanical or solenoid valve. The function of this valve is to open prior to the start of a refueling and provide a 5/8-inch diameter orifice for vapor flow during refueling, and to close when the event is completed and provide rollover protection. The function of two possible valves (and related components) which could serve this purpose are further detailed in the technological feasibility section of this document. The EPA expects the cost of this item to fall somewhere in the range of $3.00-$4.60. The EPA envisions this valve to be similar in complexity to an air management valve such as is currently used on some vehicles to feed additional air to the engine during starts. The EPA has been quoted a vendor selling price of approximately $3.50 for this valve at high production volumes. The EPA also had a contractor estimate the cost of a solenoid valve built to serve this purpose. In the report "Costs of Onboard Vapor Recovery Hardware" prepared by Mueller Associates for EPA in 1985, Mueller estimated the cost of an electronically activated solenoid valve designed to open and close in response to the start and completion of a refueling event, respectively (I-A-77). The cost of this solenoid valve, an actuator located at the fillcap, and the necessary wiring and connectors was estimated at $4.60.

Ford Motor Company and General Motors were the only two commenters to estimate the cost of a component (or components) needed to perform all the functions required of such a valve. Ford estimates the cost of a mechanical valve designed to allow for venting of refueling vapors and closure during other modes of operation at about $5.00. The system described by Ford does not presume the removal of the 0.05-inch diameter orifice of the current evaporative emission control system. Rather, Ford expects they would add the refueling control valve to the fuel tank and retain the evaporative emission orifice (which also acts to provide rollover protection in the current configurations).

General Motors estimated the cost of an electronic system similar to that described as part of EPA's cost estimate as $6.00. This includes $4.00 for the solenoid valve and $2.00 for some type of refueling sensor for which they had no particular design in mind when their comments were written.

d. Vapor Line

Refueling vapors are transported from the fuel tank to the onboard canister and from the canister to the vehicle's fuel metering system via vapor lines. In order to calculate estimated vapor line costs, three sets of information were needed: (1) vapor line material costs, (2) evaporative emission vapor configurations of current vehicles, and (3) evaporative emission vapor line configurations for onboard equipped vehicles. The vapor line used in this cost analysis is epichlorohydrin (ECO) tubing. The costs quoted in Table 2-5 are taken from the Mueller report (I-A-77). The Mueller cost estimate for ECO tubing is the cost to the automobile manufacturer for high volume purchases as quoted by a Detroit area supplier. Mueller also got a cost estimate for acrylonitrile butadiene rubber tubing, but the lower ECO cost was used in this analysis because it would also be effective. Cost estimates are given (on a unit length basis) for tubing sizes of 1/4-inch, 3/8-inch, and 5/8-inch inner diameter. The tubing costs, including any markup at the vendor level, are shown below:

1/4"	$0.27/ft
3/8"	$0.32/ft
5/8"	$0.50/ft

Depending on the layout of a particular vehicle, and considerations of available space, vehicle safety, and cost, a manufacturer may choose to locate a refueling canister in the front of the vehicle (typically in the engine compartment) or in the rear (near the fuel tank). Because of the differences between the size of the vapor lines needed to route refueling vapors to the onboard canister and the size of those needed to transport purge vapors from the canister, it appears that it would be marginally less costly to locate the canister near the fuel tanks. Because it is not possible to identify the preferred canister location for all vehicles, the vapor line cost was specified as a range bounded by EPA's best estimate of the vapor line cost for front and rear canister locations.

In this analysis, it was assumed that the amount and size of vapor lines used in the evaporative emission control system of a typical LDV would be identical to those of the typical LDT. Hence, the LDV and LDT (single tank) cost estimates are identical.

The costs do vary, however, with system configuration (partially integrated vs. integrated systems). The difference between the partially integrated and integrated system costs is due to the incremental nature of the cost estimates in this report. If an integrated system were used, some smaller evaporative system vapor lines would have to be replaced with larger refueling vapor lines. If a partially integrated system were used, not only would lines have to be replaced but, in most cases, an entirely new purge line would have to be added. In this analysis it was assumed that all vapor lines are 3/8-inch I.D. except for the refueling vent line, which must be 5/8-inch I.D. Vehicles equipped with fuel injection systems have negligible "hot soak" type emissions emanating from the fueling system, whereas carbureted vehicles would have evaporation from the carburetor bowl(s). Therefore, carbureted vehicles are equipped with a vapor line not needed for fuel-injected systems. The estimated vapor line lengths for current evaporative systems of carbureted and fuel-injected vehicles are shown below.

Description	Fuel-Injected	Carbureted
Fuel Tank Vent	8 ft.	8 ft.
Carburetor Vent	NA	3 ft.
Purge Lines	3 ft.	3 ft.

Since virtually all evaporative emission control canisters are located in the engine compartment, it was assumed for costing purposes that they are always located there.

The final set of data needed to calculate vapor line costs is the configuration of vapor lines needed for onboard (refueling and evaporative) control systems. As discussed above, the end points of the range of the vapor line cost estimate will be defined by the vapor line costs associated with front and rear canister locations. The assumed onboard vapor line configurations are shown below:

Canister Located in Engine Compartment

Description	Integrated (Fuel-Injected)	Part. Integrated (Carbureted)
Refueling/Evap Vent Line	8 ft.	8 ft.
Carburetor Vent Line	NA	3 ft.
Purge Lines	3 ft.	3 ft. + 3 ft.

Canister Located Near Fuel Tank

Description	Integrated (Fuel-Injected)	Part. Integrated (Carbureted)
Refueling/Evap Vent Line	3 ft.	3 ft.
Carburetor Vent Line	NA	3 ft.
Purge Lines	8 ft.	3 ft. + 8 ft.

Using the vapor line sizes and cost estimates given above, total incremental vapor line cost estimates can be found for integrated and partially integrated systems for both front and rear onboard canister locations. The table below shows the vapor line costs for each system evaluated in this analysis. Table 2-9 details the calculation of all vapor line cost estimates and provides information on the assumption used to calculate the vapor line costs for LDT's equipped with dual fuel tanks.

Table 2-9. VAPOR LINE COST ESTIMATES

LDV/LDT - Integrated Systems

- Canister located in engine compartment

  - Onboard system

Refueling vent	8 ft @ $0.50/ft =	$4.00
Purge line	3 ft @ $0.32/ft =	$0.96
Total		$4.96

  - Credit for current evap system

Fuel tank vent	8 ft @ $0.32/ft =	$2.56
Purge line	3 ft @ $0.32/ft =	$0.96
Total		$3.52
Incremental vapor line cost		$1.44

- Canister located near fuel tank

  - Onboard system

Refueling vent	3 ft @ $0.50/ft =	$1.50
Purge line	8 ft @ $0.32/ft =	$2.56
Total		$4.06

  - Credit for current evap system

Total		$3.52
Incremental vapor line cost		$0.54

LDV/LDT - Partially Integrated

- Canister located in engine compartment

  - Onboard System

Refueling vent	8 ft @ $0.50/ft =	$4.00
Carburetor vent	3 ft @ $0.32/ft =	$0.96
Purge line	3 ft @ $0.32/ft =	$0.96
Total		$5.92

  - Credit for current evap system

Fuel tank vent	8 ft @ $0.32/ft =	$2.56
Carburetor vent	3 ft @ $0.32/ft =	$0.96
Purge lines	3 ft @ $0.32/ft =	$0.96
Total		$4.48

Table 2-9. VAPOR LINE COST ESTIMATES
(continued)

Incremental vapor line cost		$1.44
o Canister located near fuel tank		
- Onboard system		
Refueling vent	3 ft @ $0.50/ft =	$1.50
Carburetor vent	3 ft @ $0.32/ft =	$0.96
Purge lines	8 ft @ $0.32/ft =	$2.56
	3 ft @ $0.32/ft =	$0.96
Total		$5.98
- Credit for current evap system		
Total		$4.48
Incremental vapor line cost		$1.50
Dual Tank LDT - Integrated System		
o Canisters located in engine compartment		
- Onboard system		
Refueling vent	8 ft @ $0.50/ft =	$4.00
	8 ft @ $0.50/ft =	$4.00
Purge lines	3 ft @ $0.32/ft =	$0.96
	3 ft @ $0.32/ft =	$0.96
Total		$9.92
- Credit for current evap system		
Fuel tank vents	8 ft @ $0.32/ft =	$2.56
	4 ft @ $0.32/ft =	$1.28
Purge line	3 ft @ $0.32/ft =	$0.96
Total		$4.80
Incremental vapor line cost		$5.12
o Canisters located near fuel tank		
- Onboard system		
Refueling vents	3 ft @ $0.50/ft =	$1.50
	3 ft @ $0.50/ft =	$1.50
Purge lines	8 ft @ $0.32/ft =	$2.56
	8 ft @ $0.32/ft =	$2.56
Total		$8.12
- Credit for current evap system		$4.80
Incremental vapor line cost		$3.32

Table 2-9. VAPOR LINE COST ESTIMATES
(concluded)

Dual Tank LDT - Partially Integrated System

- Canisters located in engine compartment
  - Onboard system

Refueling vent	8 ft @ $0.50/ft =	$4.00
	8 ft @ $0.50/ft =	$4.00
Carburetor vent	2 ft @ $0.32/ft =	$0.64
Purge lines	3 ft @ $0.32/ft =	$0.96
	3 ft @ $0.32/ft =	$0.96
	3 ft @ $0.32/ft =	$0.96
Total		$11.52

  - Credit for current evap system

Fuel tank vent	8 ft @ $0.32/ft =	$2.56
	4 ft @ $0.32/ft =	$1.28
Carburetor vent	3 ft @ $0.32/ft =	$0.96
Purge line	3 ft @ $0.32/ft =	$0.96
Total		$5.76

  Incremental vapor line cost $5.76

- Canisters located near fuel tank
  - Onboard system

Refueling vent	3 ft @ $0.50/ft =	$1.50
	3 ft @ $0.50/ft =	$1.50
Carburetor vent	2 ft @ $0.32/ft =	$0.64
Purge lines	8 ft @ $0.32/ft =	$2.56
	8 ft @ $0.32/ft =	$2.56
	3 ft @ $0.32/ft =	$0.96
Total		$ 9.72

  - Credit for current evap system

    Total $5.76

  Incremental vapor line cost $3.96

Ranges for Incremental Vapor Line Costs

	LDV/LDT (single)	LDT (dual)
Integrated	$0.54 - 1.44	$3.32 - 5.12
Part. Integrated	$1.44 - 1.50	$3.96 - 5.76

Ford Motor Company estimated the incremental vapor line costs as about $3.85 for LDV's and $4.10 for LDT's. General Motors estimated the incremental vapor line cost for passenger cars at $2.38. Both of these estimates fall above the cost ranges developed by EPA. The variations could be due to differences among vapor line materials, unit costs, or assumptions on system configurations. The vapor line material estimates were quoted by a Detroit area supplier who claimed that epichlorohydrin tubing is impermeable to gasoline vapors, so the unit costs should be reasonable. The other probable source of differences is in the assumed vapor line configurations. Because Ford and GM provided no details on vapor line configuration, it is impossible to directly compare methodologies. The EPA has assumed that all vapor lines (excluding the refueling vent line) are 3/8" inner diameter. In some cases these lines may be smaller than 3/8" inner diameter, which could lead to a smaller credit and higher incremental cost. On the other hand, in those situations where EPA assumed that vent and/or purge lines were added to the system, these were also assumed to be 3/8" lines that might be oversized as well, leading to a higher incremental cost. Overall, the assumption of 3/8" vapor lines should not critically impact the analysis.

e. Fill Limiter

The next component of cost in Table 2-5 is the "fill limiter." The fill limiter is a device that closes the refueling vent line when the fuel tank becomes full and indirectly forces automatic nozzle shutoff. The simplest device that could be used to accomplish this task is some kind of flotation device that would be buoyed up by the fuel rising in the tank and would seat itself in the opening to the refueling vent line as the fuel tank became full. The requirements of the fill limiter are more thoroughly described in the technological feasibility portion of this document (Section 2.1.3).

The cost of the fill limiter was taken from a 1984 report written by the American Petroleum Institute (I-F-98). Although the device for which a cost estimate is given in the API document is not identical to the fill limiter envisioned by EPA, the two appear to be of similar complexity. The cost quoted in the API document is $0.80. Since the report was written in January of 1984, the figure has been marked up by 3 percent to reflect inflation since that time. The inflation adjusted vendor cost of the fill limiter as shown in Table 2-5 is $0.82. This is basically the same cost used in the API estimate. Neither General Motors nor Ford estimated the cost of a fill limiter directly. Ford did include the fill-limiting capability in their "Rollover/Vent/Fill Valve." The cost of this valve ($5.00) falls within the range estimated by EPA for the refueling vent valve plus the fill limiter ($3.82 - $5.42).

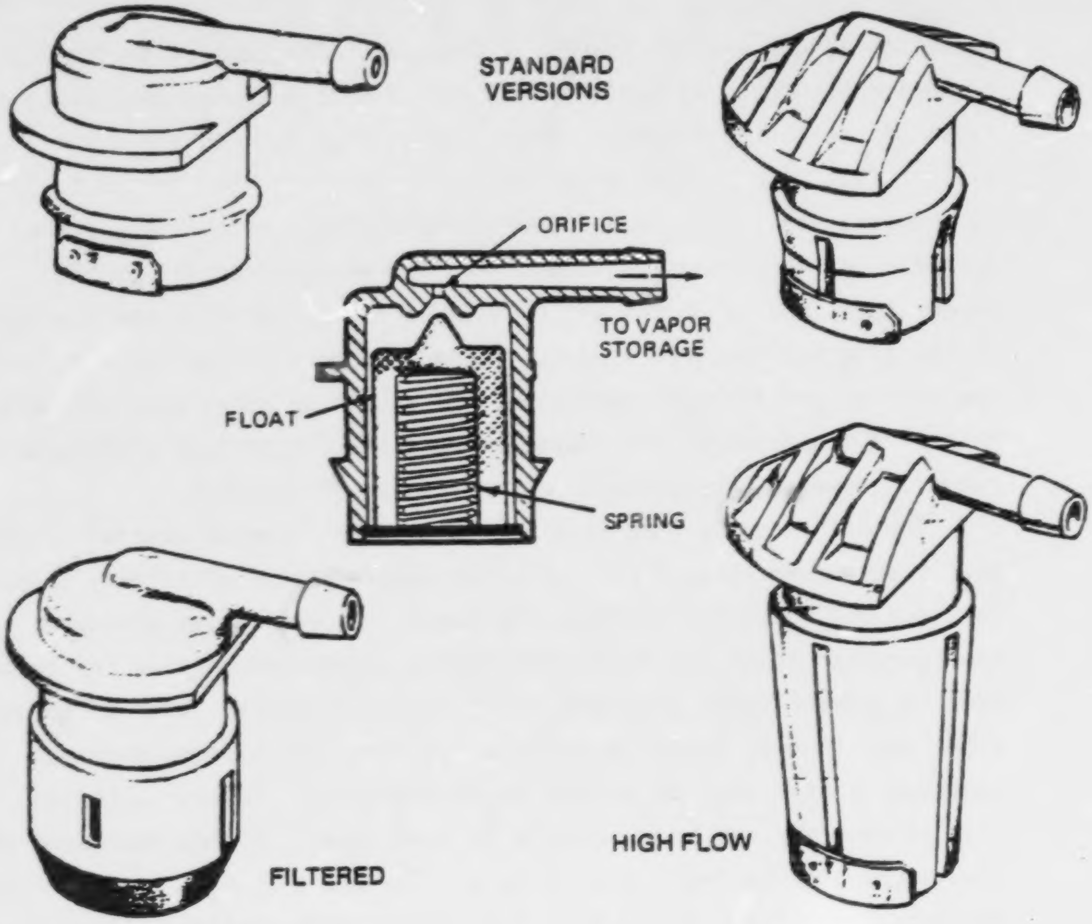
A commercially available valve, which is similar in concept to the fill limiter and seems to meet the basic functions needed, is shown in Figure 2-11. Conversations with the manufacturer indicate that this valve has a vendor price of less than $1.00.

f. Liquid/Vapor Separator

The cost of a liquid/vapor separator is also included in the onboard cost estimate. The function of the liquid/vapor separator is to remove entrained liquid droplets from the vapor stream flowing to the canister during a refueling event and return the fuel to the tank. The cost of a liquid/vapor separator was originally developed by Leroy Lindgren in his 1983 report to API (I-D-269). The original Lindgren cost ($0.71) has been marked up by 3 percent to account for inflation since the publication of the report. The liquid/vapor separator cost estimate is $0.73 in 1984 dollars.

g. Fillneck Extension - Liquid Seal

The next hardware item for which a cost is given in Table 2-5 is the J-tube fillneck extension. The standard fillneck in use today extends only a short way (if at all) into the fuel tank. In order to provide the liquid trap that is integral to refueling vapor control, it would be necessary to add a curved fillneck extension to this standard fillneck. It was assumed that all fillnecks are 2 inches in diameter and it was estimated that a 7-inch extension would be necessary. The cost for the extension was developed using cost estimations found in a report written by Leroy Lindgren for EPA in 1978.[38] In this report, Lindgren estimates the cost of a tailpipe section 35.7



The tank mounted spring balanced float valve is a low cost unit designed for venting fuel tank vapor to the carbon canister. The device employs a float which remains open under normal conditions. Should the tank level reach a critical height, the float will close the canister vent line. In the event of extreme vehicle attitude or roll-over, the float will close the canister vent line.

A filtered tank mounted spring balanced float valve is available that performs the same functions as the above sketches except the tank side of the part is filtered to prevent contaminates from entering the part which might effect float closing of the canister vent line.

For high flow applications that require a large volume of vapor venting, such as fuel injection applications, a high flow valve has been developed that has more than twice the present flow capacity without loosing other critical performance parameters.

Figure 2-11. **FLOAT VALVE**

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inches in length and 1.4 inches in diameter. The cost of the fillneck extension was found by scaling the cost of this tailpipe section by the ratio of the tubing weights. The pipe material used in the cost estimate was also changed from the stainless steel used in the tailpipe to standard steel. The manufacturing cost of the extension was then marked up by 40 percent to account for overhead and profit at the vendor level and by 35 percent to account for inflation since the time of the original Lindgren report. Table 2-10 details the calculation of the cost of the fillneck extension. It should be noted that for safety reasons a manufacturer may choose to make the J-tube from plastic or rubber. However, costs would be comparable, if not less.

The API recently completed a test program in which several liquid seal systems were tested for refueling vapor control efficiency (I-H-158). One idea evaluated was to leave the stock fillneck in its standard configuration (with the stock vent tube plugged) and rely on the incoming fuel to prevent vapor from escaping from the fillneck. With an adequately sized vent line to route vapors to a canister, the systems examined achieved greater than 98 percent efficiency in all cases. Although this concept may not be applicable in some cases, it does represent an area where cost savings could be made. The API also experimented with mechanical seals and found very high control efficiencies. Although onboard systems with a mechanical seal (and the necessary pressure relief valve) appear more costly than the liquid seal approaches, EPA still considers them a feasible alternative. The costs of a mechanical seal would be comparable to a liquid seal, but adding a pressure relief device if needed would increase costs.

h. ECU Modifications

Table 2-5 also contains a cost item for "ECU modifications." Due to the difference between evaporative and onboard system purge strategies, a cost has been included to cover the modification of vehicle purge control systems. It was assumed that 88 percent of all vehicles will be equipped with electronic controls by 1989. For those vehicles equipped with electronic controls, ECU modification would include research and development to determine the optimal purge cycle for the given vehicle and the necessary reprogramming of the unit. Mueller Associates has estimated the cost of this modification in their 1985

Table 2-10. CALCULATION OF FILLPIPE EXTENSION COST

- Calculate the weight per unit of surface area for the tailpipe section costed in the Lindgren Report.

  L = 35.7"   D = 1.4"   wt = 5.0 lb

  $A_S = L \times C = L \times \pi \times D = 35.7\ (\pi)(1.4)$

  $A_S = 35.7\ (\pi)(1.4)$

  $= 157\ \text{in}^2$

  $\text{Wt/unit } A_S = 5.0\ \text{lb}/157\ \text{in}^2 = 0.0318\ \text{lb/unit } A$

- Calculate surface area of fillneck extension needed

  L = 7 in.   D = 2 in.

  $A_S = L * \quad * D = 7(2)(\pi)$

  $= 43.4\ \text{in}^2$

- Calculate weight of material needed

  $(43.4\ \text{in}^2)(0.0318\ \text{lb/unit A}) = 1.4\ \text{lbs}$

- Calculate cost of fillpipe extension using Lindgren "complex" formula for manufacturing cost (I-A-101)

  manufacturing cost = (0.367 x weight) + 0.13
  = (0.367 x 1.4) + 0.13
  = $0.64

- Calculate vendor selling price

  vendor selling price = manufacturing cost x 1.4
  = $0.64(1.4)
  = $0.896

- Amount for inflation since 1978 (35.6%)

  1984 dollars = 1978 dollars x 1.356
  vendor selling price (1984 dollars) = $0.896(1.356)
  $1.21

---

*Reference I-A-101.

report to EPA (I-A-77). Amortized at 10 percent per annum over 5 years, this cost would be approximately $0.07 per vehicle.

For systems without electronic controls, a vacuum operated purge control system would have to be used. The same sort of research and development effort needed for the ECU-equipped systems would be needed for those without an ECU. In addition, the non-ECU vehicles could need a modified purge valve. Mueller has estimated the cost of this modification to be $0.15 per vehicle. The total purge control cost for non-ECU vehicles, amortized at 10 percent per year over 5 years, is $0.07. General Motors estimated the cost of ECU modifications as $0.25/vehicle.

i. Tank Modifications

During the first few years of a possible onboard requirement, onboard control hardware would have to be added to vehicles that were not designed specifically to accommodate this equipment. Fuel tanks would have to be modified to accept the necessary fill limiter and to provide larger orifices where necessary. In some cases, an entirely new orifice might have to be added. Although it is difficult to accurately quantify the cost of these modifications, EPA recognizes that these modifications may be necessary. Therefore, a cost of $0.50 per fuel tank has been added to cover the cost of these modifications. After the first few years of regulation, vehicle designs would inherently include provisions for onboard equipment. The $0.50/vehicle for tank modification included in the system cost covers amortization of the total investment required to modify fuel tanks over a 5-year period.

j. Packaging Cost

In order to accommodate an onboard refueling vapor control system, a number of components would have to be added to each new vehicle produced, including either a larger canister or an additional one, and some sort of fillneck modification. The addition or onboard equipment may also require modification of existing body parts of packaging hardware. For example, the underbody or underhood area on some small vehicles might have to be modified to make room for the larger onboard canister. For small vehicles, some cost would be incurred in solving such packaging problems. For large and mid-size LDV's and LDT's, virtually no costs may be incurred (I-A-77). The EPA recognizes that such a cost would be incurred in some cases and has tried to include a reasonable value to cover this cost. As in the case of fuel tank modifications, these modification costs would no longer be incurred after the first few years of regulation. Therefore, the $0.50 packaging allowance represents an investment cost amortized over a 5-year period. The $0.50 per vehicle included represents over $25 million industry-wide.

k. Assembly/Installation

The next cost item listed in Table 2-5 is an assembly cost. A component of cost for assembly has been included only for systems requiring more than one canister (separate systems or systems for vehicles with dual fuel tanks). This is because, on the margin, it should cost no more to install an integrated refueling and evaporative emission control system than it costs to install an evaporative system on a vehicle. Once again, the figure used for assembly costs is EPA's best estimate cost, lacking a significantly better estimate. Ford, General Motors, and API have all included an assembly or installation cost in their incremental cost estimates ($2.00, $0.70, and $2.42, respectively) without discussion or justification. The EPA does not believe that integrated onboard control systems would require any more assembly time than current evaporative systems. Virtually every new onboard component replaces one now present on the vehicles in some form, with the possible exception of the fill limiter and rollover valve.

l. Certification

The next two components of cost in Table 2-5 are for certification and systems engineering. The certification cost estimate is based on a 1975 EPA memo authored by Daniel P. Hardin, Jr. (I-B-38). The memo suggests that certification costs can be estimated as the sum of the costs of: (1) vehicle procurement and modification, (2) testing, and (3) mileage and maintenance. The derivations of the costs of these items are discussed below.

The average cost to produce and modify a production vehicle was estimated at $10,000 in 1975, or about $16,000 in 1984 dollars. This cost would be incurred for each durability or emissions data vehicle tested. Because durability vehicles require more maintenance than do emissions data vehicles, the mileage accumulation and maintenance costs for durability vehicles are higher than those for emissions data vehicles.

Specifically, the mileage accumulation costs for durability and emissions data vehicles were estimated to be \$3.10 and \$2.64, respectively, in 1984 dollars. Durability vehicles accumulate 50,000 miles at a cost of \$155,000 and emissions data vehicles accumulate about 4,000 miles at a cost of about \$10,500.

The final part of the certification cost is a testing cost. The Hardin memo estimates the cost of an in-house test as \$300 and the cost of a contracted test as \$600. It was assumed that 75 percent of all automobile emissions tests would be performed in-house, so the weighted average test cost is \$375. In terms of 1984 dollars, the cost is \$610. The test in 1975, however, did not include the refueling portion of the test, and the testing cost was increased to reflect this change. The changes to the Federal Test Procedure to measure refueling emissions control, as now considered by EPA, would substantially increase the per-vehicle test cost.

The test procedure changes now being considered would require two or three additional tanks of fuel (\$40) and an estimated 5 extra technician hours per test (\$150/test). The total cost per test would be:

$$\$610 + \$40 + \$150 = \$800.^{*}$$

A durability vehicle will be tested 13 times on the average, including voids, during its mileage accumulation at a cost of \$10,400. The emissions data vehicles will be tested prior to and after the 4,000-mile accumulation at a cost of \$1,600 per vehicle.

The following table shows the calculation of total certification costs for a durability vehicle and an emissions data vehicle. Similar costs were assumed for LDV's and LDT's, even though formal certification protocols differ.

	Durability	Emissions Data
Vehicle Procurement and Modification	\$ 16,000	\$ 16,000
Mileage and Maintenance	155,000	10,400
Testing Costs	10,400	1,600
Totals	\$181,400	\$ 28,000

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*Necessary changes in facilities to accommodate additional testing are estimated later in this section.

The promulgation of an onboard rule would result in all vehicle models being recertified for the first year of the regulation. Since about 10 percent of all vehicle models undergo exhaust and evaporative certification in any given year due to vehicle changes regardless of new emission standards, the cost of certifying 90 percent of the fleet for exhaust and evaporative emissions would be directly due to an onboard regulation. The per-vehicle certification cost was found by first estimating the industry-wide certification cost and then applying it to the projected 1989-93 sales volume.

The industry-wide certification cost was estimated by counting the number of durability vehicles and emissions data vehicles tested as part of the certification process for MY1984 LDV's and LDT's, and multiplying by the estimated certification costs above. The totals* were then multiplied by 0.90, amortized at 10 percent over 5 years, and spread among the projected LDV and LDT new car fleet for 1989. The table below shows the calculation of the per-vehicle certification cost for both LDV's and LDT's.

	LDV		LDT	
	DUR	ED	DUR	ED
Number of test vehicles	109	307	45	133
Cost per vehicle	$ 181K	$ 28K	$ 181K	$ 28K
Total cost	$19,729K	$8,596K	$ 8,145K	$3,724K
Sum of durability and emissions data cost	$28,325K		$11,869K	
90 percent of total	$25,492K		$10,682K	
Amortize over 5 years at 10% (amortization factor = 0.2638)	$ 6,725K		$ 2,818K	
Sales projection for 1989	11,000K		3,640K	
Cost/vehicle	$ 0.61		$ 0.77	

m. Facility Modifications

A number of comments received in response to the Strategies Document suggested that costs related to the modification and/or construction of test facilities would be incurred should an onboard regulation be adopted. The EPA recognizes that some expenditures will have to be made in order to improve and/or expand testing facilities to accommodate the added demands of the refueling test procedure. At the present time, EPA has not conducted a detailed analysis of what facilities modifications might have to be made. However, the Motor Vehicle Manufacturers Association (MVMA) has estimated the cost of facilities modifications on a per-manufacturer basis in a recent submission responding to the proposed refueling test procedure (I-D-46). MVMA has estimated the cost to each manufacturer to be $734,000. This figure includes two SHED's, two dynamometers, two fuel conditioning units, two FID's, two strip chart recorders, safety equipment, air conditioning/ventilation, and construction and installation costs. The EPA has taken this estimate at face value and used it in this analysis.

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*Technically, only the exhaust and the evaporative portion of the certification costs should be multiplied by 0.90 since all new vehicle models will have to undergo refueling certification. However, since the exhaust and the evaporative tests constitute the majority of the certification costs, including refueling certification costs in the total leads to a cost difference of less than 1 cent per vehicle.

Assuming that 35 manufacturers (total number of manufacturers certifying LDV's in 1984) will undertake such modifications, an investment of about $26 million would have to be made prior to 1989. Although probably fewer than 35 manufacturers would perform modifications as extensive as those described above, some of the larger manufacturers might incur a cost higher than $734,000. The total of $26 million is expected to represent a generous estimate of industry-wide investment. Amortizing this amount over 10 years at 10 percent and spreading the cost among an average of 14.6 million light-duty gas vehicles and trucks gives a cost of about 30 cents per vehicle.

n. Systems Engineering and Development

The final component of cost listed in Table 2-5 is for systems engineering/development (SE/D). Here the term "systems engineering/development" refers to any developmental effort involved in combining the components of the onboard control system to form a unit that interacts appropriately with the rest of the automobile. For example, the installation of onboard controls could affect a vehicle's exhaust emissions. The mileage accumulation, testing, and engineering costs incurred in altering the vehicle to adequately control the exhaust emissions would be termed "systems engineering/development" costs.

The SE/D cost estimate was made in much the same way the certification cost estimate was made. Four components went into this estimate: (1) vehicle procurement and modification, (2) mileage accumulation and maintenance costs, (3) testing costs, and (4) salary costs. These SE/D costs would be incurred for each refueling family in a manufacturer's product line. Since the parameters defining refueling families have not yet been fully defined, costs were developed on an evaporative family basis under the assumption that the number of evaporative families approximates the probable number of refueling families. An industry-wide cost was then developed and applied over the projected LDV and LDT sales.

The vehicle procurement and modification cost for SE/D is the same as that for certification, $16,000. The mileage accumulation and maintenance cost used for SE/D vehicles is the same as that used for durability vehicles in the certification cost calculation, $3.09/mile. The mileage that each vehicle will accumulate was estimated to be 8,000 miles, twice the mileage accumulated by an emissions data vehicle. The total mileage cost is $24,720 per family. Testing costs were also calculated for SE/D as they were for certification. The cost per test is $800; 25 tests were assumed for each evaporative family for a total of $20,000.

The final component in the SE/D cost is salary costs. It was estimated that salary expenditures incurred in designing and testing the onboard system for a single family would not exceed about 60 percent of the full time salaries of one engineer and one technician. Including benefits, these annual salaries were chosen as $50,000 and $35,000, respectively. The calculation of the SE/D cost for both LDV's and LDT's is shown below:

Vehicle Procurement and Modification	$16,000
Mileage Accumulation - 8,000 miles	24,720
Testing	20,000
Salary Expense	51,000
Safety Compliance Testing	34,000
Total SE/D cost per family	$146,000

The total cost was multiplied by the total number of evaporative families for both LDV's and LDT's. The projected number of refueling families was used here because it best represents the number of separate engineering and development actions that will be needed. Some refueling families may involve two or more exhaust families and thus could incur additional exhaust emissions development costs. While these would likely be small on an overall basis, an estimate was not included in this analysis because the degree of exhaust emissions development overlap and extrapolation between families could not be determined.

These costs were then amortized over a 5-year period and annual costs spread over the projected LDV and LDT sales. The calculation of cost on a per-vehicle basis is shown below. Information on safety testing costs is listed below but is described in a separate memo (I-B-20).

	LDV	LDT
Total cost per family	$146,000	$146,000
Number of families (approx.)	140	65
Industry-wide cost (thousands)	$ 20,440	$ 9,490
Amortize over 5 years at 10% (0.2638) (thousands)	$ 5,392	$ 2,503
Sales projection, 1989 (million)	11.0	3.64
Cost per vehicle	$ 0.49	$ 0.69

As can be seen in Table 2-5, an additional $0.25 has been added to the cost of control for LDT's with dual fuel tanks and is listed as an "engineering" cost. This amount has been added in recognition of the possibility that certain problems may be encountered in equipping these vehicles with onboard controls that are unique to those vehicles with very large fuel capacities. Extra R&D testing costs may be incurred in the development of systems capable of capturing and purging hydrocarbon emissions of the magnitude produced by this type of vehicle.

o. Costs Not Included in the EPA Estimate

Some items that commenters suggested be included in the onboard system cost were not included. Specifically, these are costs for maintenance, enforcement, and for taxes and insurance. As was discussed in the technological feasibility portion of this study, there is general agreement that deterioration of activated carbon canisters is not an issue and canister maintenance will not be needed. Activated carbon does lose some fraction of its working capacity through successive load/purge cycles, but this phenomenon is well known and accounted for in canister sizing. For these reasons no maintenance cost was included in the onboard cost estimate.

Although an item labeled "enforcement" does not appear in Table 2-5, enforcement costs have been indirectly included in the onboard cost estimate. The most powerful tool used to enforce motor vehicle emissions regulations is the new vehicle certification program. A substantial cost has been included in the onboard cost estimate to account for the need to recertify the LDV and LDT fleets in response to an onboard regulation. The other tools used to enforce motor vehicle emission regulations, such as selective enforcement audits and recall testing, have a negligible cost when compared to the costs involved with certification. Because of the very low marginal cost of these programs, a separate enforcement cost item has not been included in the onboard system estimate.

One commenter (I-H-101) claimed that increases in taxes and insurance (resulting from vehicle price increases caused by the addition of onboard controls) should be included as part of the societal cost of onboard control systems. In response to the question of taxes, EPA contends that taxes can be considered to be transfer payments and should therefore be excluded from the system cost. Increases in insurance expenses could be considered a societal cost, but because the fractional increase in vehicle cost caused by adding onboard controls is so small it was difficult to envision an incremental cost item for insurance costs. Therefore, insurance costs were not included in the incremental cost estimate.

2.6.2 Comparison of Cost Estimates

Each of the components of cost listed in Table 2-5 has been discussed on the previous pages. Although the subject of the factor used to account for overhead and profit at the vehicle manufacturer and dealer levels has not yet been addressed (the markup factor is discussed in the next section), onboard system cost estimates can be compared at the vendor selling price level (total system costs less manufacturer and dealer overhead and profit). The only cost estimates that contain enough component-by-component detail to suggest a comparison with the EPA estimates are those compiled by Ford, General Motors, and API. (Confidential estimates submitted by several manufacturers could not be analyzed here.) Table 2-11 shows a comparison of the incremental onboard system cost for LDV's made by EPA, GM, Ford, and API. The LDT estimates are shown in total for EPA, Ford, and API.

Table 2-11. COMPARISON OF COST ESTIMATES

	EPA[a]	Ford	GM	API
Activated Carbon	2.20	7.50[b]	5.81	6.19[c]
Canister Body	2.36			
Refueling Vent Line Valve[d]	4.60	5.00	6.00[e]	--
Vapor Line	1.56	3.85	2.38	2.66
Fill Limiter	0.82	--[f]		0.80[g]
Liquid/Vapor Separator	0.73	--	1.30	--
Fillneck Extension	1.21	--		--
ECU Modifications	0.09	--	0.25	--
Tank Modifications	0.50	--		--
Packaging	0.50	--		--
Certification	0.61	--		--
Assembly	0.09	2.00	0.70	2.42
Facilities Modifications	0.30	--		--
Engineering	0.45	--		--
Fillneck Seal		2.40	1.00	2.40
Pressure Relief		2.50		--
Purge Control Valve		--	0.73	--
Canister Brackets		1.00		--
Other		--	0.25	--
Subtotal	16.00	24.25	18.42	14.47
Credits	--	(0.80)		
TOTAL	$16.00	$23.45	$18.42	$14.47
LDT Totals	$27.00	$35.00		$16.52

[a] Weighted average of integrated and separate system costs.

[b] Total of activated carbon ($5.50) and canister ($5.00) less credit for removing evap canister (-$3.00).

[c] Total of activated carbon ($5.77) and canister ($3.62) less credit for removing evap canister (-$3.20).

[d] Includes any necessary wiring, fuel cap sensors, etc.

[e] Includes $2.00 for a "refueling sensor."

[f] Fill limiting capability is built into Ford's "Rollover/Vent/Fill Valve."

[g] Cost of a float valve/fill limiter - same as EPA cost of 0.82 (not increased for inflation).

Most of the differences between estimates for individual components have been discussed in the sections dealing with those components, but there are some areas that merit comment here. First, all of the cost estimates in Table 2-11 show a higher canister cost than does EPA. These differences are primarily due to assumptions on average fuel tank size, and/or to carbon cost estimates. Second, all of these commenters estimated costs for systems incorporating the mechanical-type fillneck seal. The modifications needed to provide a liquid fillneck seal are marginally less costly than those needed for a mechanical fillneck seal and a pressure relief device. Third, all of these comments included assembly costs which EPA believes may be overstated. Fourth, the API fuel tank valve is not equipped to handle vent line closure during driving modes, and does not provide rollover protection. Finally, a major discrepancy between cost estimates arises from the differences in the manner in which manufacturer overhead and profit are included. This issue is addressed in the following section.

2.6.3 Manufacturer Overhead and Profit

Comment: A number of commenters claimed that the markup factor of 1.27 used by EPA in the July 1984 analysis was too low, and they saw no reason for EPA to abandon the markup factor of 1.8 developed by Leroy Lindgren in his Retail Price Equivalent (RPE) cost analyses. General Motors used a markup factor of about 1.6 and claimed that EPA should use a factor in the range of 1.6 to 2.0. Ford did not use a multiplicative markup factor, but claims that a factor of about 1.8 is justified (I-H-114, I-H-117, I-H-127, I-H-132).

Response: In its 1984 analysis, EPA used the basic methodology used by Leroy Lindgren to estimate the "retail price equivalent" or cost to the consumer of an onboard system. According to Lindgren, the retail price equivalent can be obtained from the "manufacturer" level cost* by accounting for: (1) vehicle manufacturer profit, (2) vehicle manufacturer overhead, and (3) dealer overhead and profit. In the

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*The "manufacturer" level refers to the price an automobile manufacturer would have to pay to internally produce or to purchase a part from a vendor or supplier.

Strategies Document, EPA used a factor of 1.27 to account for all of these factors. The justification for the use of a markup factor of this magnitude is provided in a previous EPA analysis (I-A-29).

In choosing a markup factor, EPA attempted to account for overhead costs actually incurred and profit margins actually achieved in the automobile industry. In response to the comments claiming that EPA had underestimated overhead and profit by assuming a markup factor of 1.27, EPA had a contractor further evaluate an appropriate markup factor (I-A-106). In this report Faucett takes a weighted average of the publicly reported overhead and profit markups of the three largest American automobile manufacturers over the past 10 years. The average markup factors as a percentage of cost of sales for the light-duty market as estimated by Jack Faucett Associates are shown below:

Manufacturer Overhead	15.4
Manufacturer Profit	3.8
Manufacturer Net	19.2

The RPE must include dealer overhead and profit as shown below:

Dealer Interest Expense	1.7
Dealer Profit	2.0
Dealer Sales Commission	2.0
Dealer Net	5.7

The retail price equivalent of the onboard control system was calculated from the vendor selling price in the following manner:

RPE = [Vendor Selling Price (excluding engineering)
x (1.192)(1.057)] + engineering costs.

As mentioned above, many of the automobile manufacturers claimed that a much higher markup factor was appropriate. It is clear from the Faucett report that overhead as a percentage of cost of sales has been declining in recent years, and the average manufacturer profit margin experienced over the past 10 years is only about 3.8 percent. Manufacturers and dealers would prefer to see higher profit margins, and they have experienced periods when overhead represents a larger percentage of the cost of sales than estimated in the Faucett report. The EPA, however, is attempting to use an industry-wide, long-term average value, and the 1.26 markup factor is representative. For further discussion of markup factors, the reader is referred to the Faucett report.

2.6.4 Excess Evaporative Emissions

Comment: Several commenters (e.g., I-H-114, I-H-118, I-H-127) noted that, in the July 1984 EPA analysis, onboard controls were evaluated both with and without substantial emission reduction credits associated with the control of excess evaporative emissions. These commenters went on to argue that the excess evaporative emissions issue is separate from the refueling emissions question, and should not be considered in the evaluation of onboard controls. The commenters stated that onboard controls should be evaluated only in terms of the costs and benefits associated with the control of refueling emissions.

Response: During the past few years, EPA has tested several in-use vehicles for their compliance with evaporative emission standards. The results of this testing have suggested that many vehicles are exceeding these standards by substantial margins. The reasons for the in-use failures can basically be traced to the upward trend in the volatility of commercially available gasoline coupled with vehicle purge control system underdesign (I-A-66). Preliminary engineering analysis indicates that properly designed onboard control systems coupled with test procedure and certification fuel changes would help control these excess evaporative emissions with no significant marginal impact on onboard costs. Therefore, the 1984 analysis included a scenario in which onboard control systems were credited with the control of excess evaporative emissions.

In response to the comments concerning excess evaporative emissions, EPA attempted to evaluate the costs and benefits of onboard control incremental to those associated with the control of excess evaporative emissions. Because properly designed onboard systems could control excess evaporative emissions, the total onboard system costs given previously in this section are not incremental to the costs of vehicle excess evaporative emission controls. In order to get the incremental hardware cost, the cost of the vehicle excess evaporative emission controls should be deducted from the onboard hardware cost.

In a recent EPA study on gasoline volatility and evaporative emissions, several strategies for the control of excess evaporative emissions were evaluated (I-A-66). One of these strategies, referred to as the vehicle control approach, is to increase the volatility of the certification fuel from 9.0 to 11.5 psi and make other test procedure changes to require improved purge capability. This would require vehicle manufacturers to improve evaporative emission control systems to capture and purge a larger evaporative load. This would have implications for onboard costs, since onboard systems and the refueling test procedure would accomplish, at least to some extent, the same ends. For example, vehicle excess evaporative emission controls implemented concurrently with onboard would reduce costs in areas such as canister size, purge control, and certification. Therefore, the cost of the onboard system incremental to the costs associated with the control of excess evaporative emissions can be estimated by subtracting the costs associated with the vehicle excess evaporative control approach (taken from the volatility study mentioned above) from the onboard hardware estimates provided earlier. The calculations of the incremental onboard costs are shown below. HDGV costs are discussed more fully in the following section.

Onboard Hardware Costs Incremental to Excess Evaporative Emission Control

	LDV	LDT*	HDGV*
1989-1993	$20.00	$27.20	$34.80
	2.90	3.80	4.20
	17.10	23.40	30.60
1994-1999	17.70	24.20	29.80
	2.00	2.60	3.50
	15.70	21.60	26.30
2000+	16.30	22.60	29.40
	2.00	2.60	3.50
	14.30	20.00	25.90

The incremental onboard hardware costs (bottom line values above) are the costs used to calculate the total incremental onboard cost and cost effectiveness values discussed elsewhere in this document.

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*Since only a single cost is given for the vehicle evaporative emission control system improvements for LDT's and HDGV's, the weighted average LDT and HDGV onboard hardware costs are shown.

Subtracting the excess evaporative emission control cost from the total onboard system cost separates the two areas with regard to costs. To be consistent, the benefits of the control strategies must also be separated. In the cost effectiveness calculations presented elsewhere in this study, only the benefits associated with capturing refueling vapors are included in the incremental cost effectiveness of onboard controls. The benefits in terms of excess evaporative emission reductions associated with vehicle controls are not included.

Another benefit of evaporative emission control is a recovery credit for the consumption of previously escaping evaporative hydrocarbons. In the volatility study, the cost of the vehicle changes needed to control excess evaporative emissions were reduced to reflect a cost savings associated with the use of the controlled evaporative hydrocarbons (I-A-66). This evaporative emission recovery credit has also been omitted from the incremental analysis of onboard controls.

2.6.5 Heavy-Duty Gasoline Fueled Vehicles

a. Introduction

As discussed in other portions of this document, a number of commenters stated that onboard controls should be applied to HDGV's, and not applying such controls reduces the overall efficiency of the onboard approach.

In Appendix C of the July 1984 EPA analysis, the technological feasibility of onboard controls for heavy-duty gasoline vehicles (HDGV's) was briefly discussed in qualitative terms. In that document, it was postulated that HDGV's could be equipped with onboard controls. Although the feasibility of onboard controls for HDGV's has not been physically demonstrated since the publication of the 1984 analysis, there is no information that suggests the contrary.

One possible area of concern surrounding the feasibility of onboard controls for HDGV's is the ability of the HDGV to purge the refueling/evaporative canister(s) of a large amount of hydrocarbons without unacceptable impacts on exhaust emissions and driveability. For many of the smaller HDGV's, the task will be nearly identical to that of equipping LDT's with onboard controls. The fuel system and emission control technologies used on the light HDGV's in the early 1990s are expected to be quite similar to those used on larger LDT's. Fuel tank capacities for these vehicles are also expected to be quite similar.

There are more areas of uncertainty, however, for the heavier trucks. First, the larger trucks generally have larger fuel tanks and hence a larger refueling load to handle. Also, and of greater concern, the fuel and emission control systems of these heavier trucks are generally less advanced than those of the lighter HDGV's. For example, many of the truck models may not use feedback fuel control systems and some vehicles may not even be catalyst equipped. Although these heavier HDGV's present a more difficult engineering challenge, there is no reason to conclude that they could not be equipped with onboard controls. Indeed, other control technologies such as the fuel bladder could be used to reduce the refueling and evaporative emissions vapor load, but costs may be an issue (I-B-41).

Since it appears feasible to equip HDGV's with onboard controls and there would be air quality and health benefits associated with such control, EPA included HDGV's in the onboard control option evaluated in this document. The EPA is currently preparing a report that looks at the feasibility, costs, and cost effectiveness of onboard controls for HDGV's in more detail, but the report was incomplete at the time this analysis was performed. In order to include HDGV's in the onboard analysis, a preliminary estimate of the cost of onboard systems for heavy-duty gasoline vehicles was made. The cost estimate is briefly discussed in the following paragraphs.*

b. Onboard System Costs - HDGV's

Table 2-12 shows the detailed estimates for the costs of onboard control systems for HDGV's. Most of the estimates were derived using the same methodologies used in the light-duty analysis. In fact, many of the costs are identical to those used there. Because of the similarities in the costing methodologies, the heavy-duty cost analysis is not discussed in detail in this section. In order to provide a basis for analyzing the validity of the cost estimations, some of the key assumptions used in the analysis are described below.

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*A preliminary estimate of the cost effectiveness of onboard controls for HDGV's can be found in the Public Docket (I-B-42).

Table 2-12. ONBOARD COSTS - HDGV's

	Class IIb		Class VI	
Fuel Tank Configuration	Single	Dual	Single	Dual
Fleet Composition (%)	80	20	85	15
Activated Carbon	3.60	7.20	5.40	14.40
Canister Body	3.16	7.52	7.17	15.74
Refueling Line Valve	4.60	9.20	4.60	9.20
Vapor Line	1.54	5.24	5.36	10.08
Fill Limiter	0.82	1.64	0.82	1.64
Liquid/Vapor Separator	0.73	1.46	0.73	1.46
Fillneck Extension	1.21	2.42	1.21	2.42
Mechanical Seal	--	--	1.12	2.24
Pressure Relief	--	--	2.50	5.00
Tank Modifications	0.50	1.00	0.50	1.00
Packaging	0.50	0.50	--	--
Assembly	0.00	0.75	--	0.00
Certification	2.00	2.00	2.00	2.00
Facilities Modifications	0.30	0.30	0.30	0.30
Vendor Cost	18.96	39.23	31.71	65.48
Markup by 1.27[a]	24.08	49.82	40.27	83.16
Systems Engineering Development	0.69	0.69	1.50	1.50
Purge System Improvements	0.25	0.50	0.25	0.50
Total RPE Cost	25.02	51.01	42.02	85.16
Total Costs, 1989	$30.22		$48.49	
1994 - 1999[b]	$25.29		$43.39	
2000 and Later MY Costs[c]	$24.91		$43.04	

[a] See docket item (I-A-74).

[b] Following amortization of the "5-year" fixed costs.

[c] Following amortization of the "10-year" fixed costs.

[d] Costs shown here differ slightly from those in docket item (I-B-37) due to correction of computational errors.

(1) Fleet Composition

No data were available at the time of this analysis with which to accurately categorize the HDGV fleet in terms of chassis designs, vehicle lengths, and other key vehicle parameters necessary to characterize HDGV's and their fuel systems by weight class. It was known, however, that about 90 percent of all HDGV's fall in Classes IIb (8,501-10,000 lbs), VI (19,501-26,000 lbs), and VII (26,001-33,000 lbs), with about three-fourths of these falling in Class IIb. In order to simplify the analysis, it was assumed that 75 percent of all HDGV's can be classified as Class IIb trucks and all remaining HDGV's fall in Class VI. A number of local vehicles were evaluated to get a preliminary idea of the Class IIb and VI HDGVs' vehicle and fuel/vapor system characteristics needed for this analysis.

(2) Fuel Tank Capacities

In order to calculate carbon bed volumes and their costs it was necessary to estimate fuel tank capacities for the various vehicle configurations analyzed. The fuel tank capacities selected for Class IIb trucks were 20 and 40 gallons for single and dual tank trucks, respectively. The single tank capacity of 20 gallons was chosen based on recent certification information for Class IIb trucks. The dual tank usage rate of 20 percent used in the LDT analysis was applied to the IIb trucks as well.

The single fuel tank capacity for Class VI vehicles (30 gallons) was based on the inspection of a number of Class VI HDGV's used in local service. The dual tank fuel capacity was estimated by assuming a 500-mile driving range and applying the projected 1994 fuel economy for Class VI HDGV's (6.17 mpg) (I-A-99). This gives an estimated fuel tank capacity of about 81 gallons, which was rounded to 80 gallons (two 40-gallon tanks). The dual tank usage rate for the Class VI trucks was approximated by the fraction of the Class VI HDGV's that are engaged in short and long range travel (i.e., not strictly in local service). Information from the 1977 Census of Transportation suggests that less than 15 percent of the Class VI HDGV's are used for non-local business (I-F-142). Therefore, 15 percent was chosen as the dual tank usage rate.

(3) Separate vs. Integrated Systems

Because of differences in the assumptions concerning the number of canisters needed to control refueling and evaporative emissions (outlined in the light-duty analysis), the cost of an integrated system differs from that of a separate system. As in the light-duty analysis, the proportion of HDGV's using integrated systems was estimated by the proportion of fuel-injected vehicles in the fleet. Due to the expected similarities between the fuel and emission control technologies of LDT's and Class IIb HDGV's, the fuel-injected fraction for LDT's (88 percent) was applied to the IIb trucks. All Class VI HDGV's were assumed to use separate systems, because in the near term few are expected to use fuel injection.

(4) Emission Rate and Canister Sizing

Refueling emission rates are somewhat sensitive to fuel tank and fillneck configurations. Since the fuel tank configurations of the heavier HDGV's differ significantly from those of LDV's and LDT's, it would be desirable to have a refueling emission rate for HDGV's alone. No data base with which to estimate this emission rate was available at the time this analysis was performed, however. The only data available were the data used to estimate an emission rate for LDV's and LDT's. Therefore, the emission rate used to size canisters for LDV's and LDT's (7.0 g/gal) was used in this analysis.

(5) Miscellaneous

The cost estimations for activated carbon, canister body, and vapor lines were made using the techniques used in the light-duty cost analysis and estimates of typical Class IIb and VI truck configurations. The costs estimated for refueling vent line solenoid valves, fill limiters, liquid/vapor separators, fillneck extension, fuel tank modification, packaging, assembly, and facilities modifications (and engineering/development costs for the IIb trucks) are identical to those used in the light-duty analysis. Due to the limited fillneck height available on most of the heavier HDGV's,* it was assumed that manufacturers of the heavier trucks would choose to use mechanical fillneck seals. The cost included for each fillneck seal was that used in the July 1984 analysis, $1.12. In conjunction with the use of a mechanical seal, a pressure relief device of some sort would have to be used. In their comments on the 1984 EPA analysis (I-H-114), Ford Motor Company estimated the cost of a pressure relief device to be $2.50. To be conservative, this cost was used in the HDGV analysis. The remaining costs are EPA best estimates based on available information.

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*The gas cap on the fuel tanks of most of the heavier HDGV's is typically integral with the tank (i.e., little or no fill height).

2.7 FUEL CONSUMPTION BENEFITS OF ONBOARD

In the July 1984 EPA analysis, the costs of onboard control are developed in Appendix C. In the analysis of onboard control costs presented in that appendix, the fuel economy impacts of onboard control are briefly considered. The discussion presented in Appendix C states that the implementation of an onboard regulation would have no net impact on fuel economy. Although the discussion asserts that the recovery of refueling vapors could marginally reduce fuel consumption, it also recognizes that the added weight of the onboard control system would reduce the vehicle's fuel economy. The assumption was made that these two factors roughly offset one another.

2.7.1 Recovery Credits for Light-Duty Vehicles

Comment: A number of commenters stated that a net fuel consumption benefit would be realized if onboard controls were required (I-H-11, I-H-40, I-H-70, I-H-102, I-H-108, I-H-119).

Response: In response to these comments, EPA examined the fuel economy impacts of onboard control in more detail. The general conclusion of the analysis is that the addition of onboard controls to light-duty vehicles (LDV's) and light-duty trucks (LDT's) would marginally decrease their lifetime fuel consumption. Although the magnitude of the benefit is not large as a percentage of fuel consumed over the life of the vehicle, the benefit could reduce the consumer's cost of control substantially. The remainder of this section details the calculation of the net fuel consumption improvement.

The fuel consumption analysis can be conveniently broken into three parts. The first part is the calculation of the fuel economy penalty caused by the additional weight of the onboard system. This calculation involves the average weights of the various classes of LDV's and LDT's, the estimated weight of the onboard system, and the sensitivity of fuel economy to weight for the various vehicle classes. The second part of the analysis is the calculation of a gross fuel consumption improvement derived from the recovery of refueling vapors. This calculation involves: (1) calculation of the average total weight of hydrocarbons recovered over the life of a vehicle, (2) calculation of the energy value of the fuel recovered, and (3) conversion of the results of these calculations to equivalent gallons of fuel saved. The final step in the analysis is the calculation of the net fuel consumption benefit from onboard control (gross savings - weight penalty) and the conversion of the results to appropriate units. In this analysis, the results are presented in terms of both quantity of fuel saved over the life of the vehicle and the net present dollar value of the lifetime fuel savings.

2.7.1.1 Weight penalty. Four pieces of information are needed in order to calculate the fuel economy penalty caused by the addition of onboard controls for each class of vehicle: (1) average vehicle weight, (2) estimated average control system weight, (3) average fuel economy, and (4) sensitivity of fuel economy to changes in vehicle weight. The sources of these pieces of information are documented below. Then a detailed description of the calculation of the penalty in fuel economy associated with the added weight of an onboard system is given.

a. Average Vehicle Weight

The average vehicle weights for LDV's and LDT's were taken from SAE Technical Paper 850550 entitled "Light-Duty Automotive Fuel Economy ... Trends thru 1985" (I-A-104). This paper gives a fleetwide salesweighted average vehicle inertia weight for both light-duty vehicles (3,082 lbs., Table 1) and light-duty trucks (3,832 lbs., Table B-2) for 1985. The weighted average vehicle weights were calculated using manufacturer-specific sales projections for 1985.

b. Average Control System Weight

The average control system weights for LDV's and LDT's were developed by estimating the incremental increase in vehicle weight associated with each component of the refueling control system. The components for which weights were estimated are those that make up the onboard control system discussed elsewhere in this study. The components and their estimated incremental weights are shown below:

	LDV	LDT	LDT (dual)
Carbon	1.6 lb.	2.2 lb.	4.3 lb.
Canister	0.8	0.9	1.8
Vapor Line*	0.7	0.7	2.2
Fillneck Extension	1.4	1.4	2.8

	LDV	LDT	LDT (dual)
Liquid/Vapor Separator	0.4	0.4	0.9
Rollover/Vent Valve	0.4	0.4	0.8
Fill Limiter	0.4	0.4	0.9
LDT Weighted Average**	5.7	6.3	13.6

The carbon weights were found by applying the activated carbon density used in the canister sizing analysis (300 g/liter) to the volume of carbon needed for each vehicle class. The canister shell, vapor line, and rollover valve weights were found by weighing representative components and, when necessary, scaling the weights to reflect size/capacity differences. The computation of these estimated weights is detailed in Table 2-13. The fillneck extension weight (1.4 pounds) was estimated as part of the calculation of the cost of that component. The weight of the liquid/vapor separator was taken from the Lindgren report on onboard costs (I-D-269). Due to a lack of better information, the fill limiter weight was taken to equal the weight of the liquid/vapor separator under the assumption that these components would be of similar material, size, and complexity.

The system weights shown above are intended to cover the total incremental weight increase associated with equipping LDV's and LDT's with onboard refueling control systems. One large component of the

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* Vapor line weight estimates are weighted 88 percent for integrated and 12 percent for separate systems.

**As outlined in the section on onboard system costs, approximately 80 percent of the vehicles in the LDT fleet are equipped with a single fuel tank and 20 percent are equipped with dual fuel tanks. Throughout this section, the "weighted average" figures for LDT's are based on this 80-20 weighting.

Table 2-13. COMPUTATION OF ONBOARD COMPONENT WEIGHTS

Carbon - 300 grams/liter = 0.66 lb/liter
LDV 2.44 liter x 0.66 = 1.6 lb
LDT 3.26 liter x 0.66 = 2.2 lb
Dual 6.52 liter x 0.66 = 4.3 lb

Canister (Body, Grid, Filters)

GM 1,500 ml canister - mass measured @ EPA
202 g - 200 g = 0.445 lb

scale by ratio of surface area - or equivalently square of areas.

1,500 ml canister w/h = d $r'^2 = 38.5$

LDV - 2,440 + 850 = 3,290 $r''^2 = 65.0$

$$\frac{r''^2}{r'^2} = \frac{65.0}{38.5} = 1.7 \qquad 1.7 \times 0.445 \text{ lb.} = 0.76 \approx 0.8 \text{ lb.}$$

LDT 3,260 + 850 = 4,110 $r'''^{2}3 = 75.4$

$$\frac{r'''^2}{r'^2} = \frac{75.4}{38.5} = 2.0 \qquad 2.0 \times 0.445 \text{ lb.} = 0.87 \approx 0.9 \text{ lb.}$$

dual tank trucks - 1.8 lb

Vapor Line

5/8" I.D. line - mass of 1 ft. section measured - 91 g/ft
3/8" I.D. 3/5 x 91 g/ft ≈ 55 g/ft

o LDV/LDT

Integrated system - replace 8 ft of 3/8" with 8 ft of 5/8"
8 ft (91 g/ft - 55 g/ft) = 288 g ≈ 0.6 lb

Separate System:

- replace 8 ft of 3/8" with 8 ft of 5/8"
- add 3 ft of 3/8"

288 g + (3 ft x 55 g/ft) = 453 g

≈ 1 lb

- weighted average - 0.7 lb

Table 2-13. COMPUTATION OF ONBOARD COMPONENT WEIGHTS (concluded)

o Dual tank trucks

Integrated System:			
- Add:	16 ft. of 5/8" -	1,456 g	
	6 ft. of 3/8" -	330 g	
		1,786 g	
- Remove:	15 ft. of 3/8" -	825 g	
Net Mass		961 g	≅ 2.1 lb
Separate System:			
- Add:	18 ft. of 5/8" -	1,456 g	
	11 ft. of 3/8" -	605 g	
		2,061 g	
- Remove:	18 ft. of 3/8" -	990 g	
Net Mass		1,071 g	≅ 2.4 lb
Weighted Average			2.2 lb

increase in vehicle weight is additional activated carbon used to collect and store refueling emissions. It appears that the additional hydrocarbon storage capacity could be used to collect the "excess evaporative emissions" that have recently been measured on in-use vehicles. The EPA is currently evaluating strategies to control these excess emissions in a rulemaking separate from an onboard rulemaking. In this analysis, EPA is attempting to separate the costs and benefits of the two problems, i.e., attempting to evaluate the costs and benefits of an onboard regulation incremental to those of excess evaporative emission controls.

In order to evaluate the weight penalty associated with refueling controls incremental to that of excess evaporative emission controls, it was necessary to subtract the incremental weight of the excess evaporative control system expansion from that of the onboard system. The increases in vehicle weights associated with vehicle control of excess evaporative emissions were estimated as part of the analysis in the recent EPA study of fuel volatility (I-A-66). The weight increase used in the volatility study for light-duty vehicles was 0.8 pound and that for light-duty trucks was 1.1 pounds. The calculation of the incremental onboard system weights are shown following:

	LDV	LDT	LDT (dual tank)
Onboard system weight incremental to current evap system (lb)	5.7	6.4	13.7
Excess evap control system weight incremental to current evap system (lb)	0.8	1.1	1.1
Onboard system weight incremental to excess evap control system weight (lb)	4.9	5.3	12.6

As part of their comments on the final volatility study, General Motors raised an issue with EPA regarding the weight impact associated with adding components to a vehicle. GM claimed that adding "x" pounds of equipment would lead to a total increase in vehicle weight of 1.7(x) pounds. The factor of 70 percent added to the component weight covers the weight of the additional vehicular structure that would have to be added to carry the added components. Although vehicle structure might not be improved in equipping vehicles with onboard controls during the first few years of a regulation, GM claims that as vehicle models changed and new models were designed to include onboard controls, the vehicular structure would be designed to carry the added weight of the onboard system. This assertion suggests that the EPA estimate of the weight impact of adding an onboard system is lower than it ought to be. Due to the late date at which GM presented this information to EPA, it has been more thoroughly evaluated in a separate analysis (I-B-22).

There is some conservatism built into the weight estimate. For purposes of the analysis of the weight penalty, it has been assumed that all canisters would be located in the engine compartment of the vehicle. However, some manufacturers could choose to locate the onboard canister(s) near the fuel tank, which could lead to a somewhat lower total vapor line weight, since less 5/8" hose would be used. This current assumption leads to the need for a longer refueling vent line (5/8" inner diameter) and a marginally higher vapor line weight.

In this section of the analysis, incremental weight penalties for a system to control refueling emissions have been developed. This information will be used to estimate the potential fuel consumption benefits of onboard controls. The potential fuel consumption benefits of vehicle excess evaporative controls were addressed in the recent EPA study of gasoline volatility (I-A-66), and will not be further evaluated here.

c. Fuel Economy Estimates

Fuel economy estimates are those used in EPA's MOBILE3 fuel consumption model (I-A-99, I-B-37). The table below shows estimated average in-use fuel economy for LDV's and LDT's for model years 1989, 1994, and 2000. These three model years have been chosen because the costs of onboard control have been estimated for these 3 years and this makes it possible to compare the recovery credits and costs of onboard control in the same time frame.

Year	LDV	LDT*
1989	24.61	18.43
1994	26.64	18.99
2000	29.13	20.56

d. Fuel Economy/Weight Sensitivity

The final component used in calculating the fuel economy penalty was the sensitivity of fuel economy to changes in vehicle weight for LDV's and LDT's. These sensitivities have been calculated by Energy and Environmental Analysis, Inc., for the U.S. Department of Energy (I-F-135). The sensitivities are presented in terms of the quotient of percent change in fuel economy per percent change in vehicle weight. The sensitivities are presented for both LDV's (-0.329) and LDT's (-0.402). The sensitivities do vary a great deal from manufacturer to manufacturer, but for a fleetwide average the sensitivities presented above are the best information available to EPA. The sensitivities should provide a reasonable estimate of the decrease in fuel economy caused by increasing vehicle weights.

These sensitivities were used in the analysis presented in the EPA study on fuel volatility referred to earlier (I-A-66). In that report, the sensitivities were used to calculate the fuel economy penalty that would be incurred as a result of the vehicle weight increase associated with the vehicle based control of excess evaporative emissions.

e. Calculation of Weight Penalties

The fuel economy penalty associated with the weight of the onboard hardware can now be calculated using the information presented above. The steps in the calculation of the weight penalties are described below and summarized in the table which follows the discussion.

The percent change in vehicle weight was calculated by dividing the average incremental weight of the control system by the average vehicle weight for each vehicle class of interest. The percent change in vehicle weight was then multiplied by the sensitivity factor to give a percent change in fuel economy. Next, the projected average lifetime fuel consumption was calculated for the various vehicle classes. This was done by dividing the estimated average lifetime vehicle miles travelled by the projected average fuel economy for each vehicle class. The percent change in fuel economy was then applied to the lifetime vehicle fuel consumption to produce the fuel consumption penalty associated with adding onboard controls.*

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*The fuel economies of single and dual tank trucks have not been presented separately even though dual tanks are used predominantly on the larger LDT's. Using the control system weights and applying them to the weighted average LDT vehicle weight will produce representative LDT fuel economy penalties.

		LDV	LDT	Dual
1)	Average control system weight (lbs)	4.9	5.3	12.6
2)	Average vehicle weight (lbs)	3,082	3,832	3,832
3)	Percent change in weight (%)	0.159	0.138	0.329
4)	Sensitivity factor (dimensionless)	-0.329	-0.402	-0.402
5)	Percent change in fuel economy (mpg) (%)	-0.052	-0.056	-0.132
6)	1989 projected fuel economy (mpg)	24.61	18.43	18.43
7)	Projected average lifetime mileage (miles)	100,000	120,000	120,000
8)	Lifetime fuel consumption (gal)	4,063	6,511	6,511
9)	Lifetime weight penalty (gal)	2.1	3.6	8.6

Using similar calculations, the weight penalties for each model year and vehicle class of interest are shown next:

	Weight Penalties (gallons/lifetime)		
	1989	1994	2000
LDV	2.1	2.0	1.8
LDT	3.6	3.5	3.3
LDT (Dual)	8.6	8.4	7.8

2.7.1.2 Gross fuel consumption credit. This section details the calculation of the gross fuel consumption benefit related to onboard control. The gross fuel consumption benefit related to the recovery of refueling vapors was found using: (1) the uncontrolled refueling emission factor, (2) the theoretical control efficiency of onboard systems, (3) the energy content of typical gasoline expressed on a volume basis (Btu/gal), and (4) the energy content of the refueling vapors expressed on a weight basis (Btu/lb). Each of these factors is discussed below.

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*Although the sensitivity factor is presented in terms of fuel economy, it can be applied equally well to fuel consumption because it is expressed in terms of percentage change. Since fuel consumption and fuel economy are inversely related, the direction of change is opposite, i.e., an increase in fuel economy leads to a decrease in fuel consumption.

a. Uncontrolled Emission Rate

The uncontrolled emission rate was developed from a series of refueling SHED tests conducted at the EPA Motor Vehicle Emissions Laboratory in Ann Arbor. The emission rate was developed by applying the national average conditions of temperature and fuel volatility to a multiple regression equation developed from the results of the uncontrolled refueling emission test program. The details of this test program and the development of the regression equation are presented in an EPA technical report (I-A-69). The national average conditions were chosen so that the emission rate calculated would give an estimate of the total potential refueling emissions that could be controlled by onboard systems, given perfect control efficiency. The emission rate that results when the national average conditions (T_D = 68.9°F, T = 4.4°F, RVP = 12.6) are inserted in the regression equation is 5.9 grams of hydrocarbons emitted per gallon of fuel dispensed.

b. Control Efficiency

The theoretical control efficiency of onboard control systems has been well demonstrated over the past several years. In 1978, the American Petroleum Institute (API) evaluated the efficiency of an onboard control system equipped with a mechanical seal built into the vehicle fillneck and observed efficiencies of greater than 98 percent (I-F-17). In a more extensive set of tests performed on these vehicles using a nozzle-based seal, refueling emissions were also controlled to between 96 and 99.8 percent. The API supplemented the work done in 1978 with a study performed in 1985 (I-H-158). In the 1985 onboard demonstration, Mobil Research and Development experimented with a number of "liquid seal" concepts and observed control efficiencies of greater than 98 percent. Exxon Research and Engineering equipped two vehicles with onboard control systems using liquid seals and measured refueling emissions using 9, 10.5, and 12 psi RVP fuels. Both Exxon vehicles achieved refueling emission control efficiencies of greater than 98 percent. For a further description of the API work see docket items (I-F-17) and (I-H-158).

The EPA has also done some developmental work with an onboard equipped vehicle utilizing a J-tube type fillneck seal (I-A-93, I-A-109). In refueling emission control tests performed at the conditions outlined in EPA's draft Refueling Test Procedure (I-A-71), refueling emissions were controlled to between 95 and 99 percent with an average of 97.6 percent. In each of the test programs discussed above, the average efficiency of refueling emission control was shown to be greater than 97 percent. Also, these were prototype systems which could be expected to perform less efficiently than systems designed for the vehicle and installed during manufacture. Therefore, EPA has chosen a theoretical efficiency of 97 percent under the assumption that this is a readily attainable value, and may be conservatively low.

The theoretical control efficiency of the system does not reflect tampering effects. These factors are accounted for, however, in the fuel consumption figures used to calculate the nationwide, long-term cost of control and cost effectiveness presented in the regulatory impact analysis document (Reference 2 of Chapter 1). The effect of reduced control due to tampering is accounted for in that manner.

c. Energy Content of Gasoline and Refueling Vapors

In order to calculate the net fuel consumption benefit associated with onboard controls, the weight penalty and lifetime recovery credits have to be expressed in equivalent units (e.g., gallons of gasoline). This is not as simple as it initially appears, however. The difficulty arises because of the fact that hydrocarbon vapors collected during a refueling event are composed of a different combination of constituents than is the liquid fuel dispensed in that same event. About 75 percent of the vapor is comprised of paraffins with carbon numbers of 4 and 5. The liquid gasoline, on the other hand, has a much lower concentration of these lighter ends and a much higher concentration of aromatic hydrocarbons with carbon numbers from 7 to 10. The difference in composition means that the vapor has a different density (in a condensed form) and energy content than the same mass of liquid fuel.

Since the composition of refueling vapor is not identical to the composition of the gasoline from which it comes, it was necessary to estimate the difference in their energy contents. It would have been ideal if the energy content and density of a "typical" fuel and its vapor could be developed. This requires a detailed knowledge of the properties of fuels and their vapors as consumed throughout the United

States for all seasons of the year. No data base of this sort is currently available to EPA. However, EPA did have a study that characterized liquid fuel and associated vapors for a number of fuels dispensed in northeastern cities during the month of July 1980 (I-A-58). The study was done by Midwest Research Institute (MRI) of Kansas City under contract to EPA's Office of Air Quality Planning and Standards. Although the information is not ideal, it is the best information currently available to EPA, and it was used in these calculations.

The MRI study reports the weight- and volume-percent of hydrocarbons by category (paraffin, olefin, or aromatic) and carbon number for 20 fuels obtained from retail outlets. Since 1989 and later model year vehicles will all burn unleaded fuels, the results from the seven leaded fuel samples were not included in this analysis. Of the 13 unleaded samples remaining, 8 are regular and 5 are premium. Since survey data show that about 75 percent of all unleaded fuel sold is regular, the data have been weighted 75 percent regular and 25 percent premium (I-F-144).

Table 2-14 shows the weighted average volume percent of each hydrocarbon constituent in the liquid phase of the unleaded samples. Table 2-15 shows the average weight percent of the hydrocarbon constituents in the vapor phase of the samples. Given the weightings in Tables 2-14 and 2-15, the properties of the typical fuel and its vapors can be estimated from the properties of the constituents. The density and heat of combustion for each of the hydrocarbons in these tables are presented in Table 2-16. The values in Table 2-16 were taken from the Technical Data Book - Petroleum Refining, Volume I as compiled by the American Petroleum Institute (I-F-143). Table 2-16 shows heats of combustion in terms of Btu/gal only. In order to use this information with the weightings in Table 2-15, the heats of combustion had to be converted to Btu/lb. This conversion was done using the density figures also shown in Table 2-16. The liquid unleaded fuel samples in the "Northeast Corridor ..." study (I-A-58) had a calculated weighted average heat of combustion of 113,800 Btu/gal and a density of 6.13 lb/gal. The vapor associated with these samples had a calculated weighted average heat of combustion of 97,900 Btu/lb and a density, in condensed form, of 5.07 lb/gal.

Table 2-14. LIQUID COMPOSITION OF SEVERAL GASOLINE SAMPLES (VOLUME PERCENT)*

C# Paraffins	Regular	Premium	Wtd 75/25
3	0.1	0.1	0.1
4	6.0	4.6	5.6
5	14.6	14.4	14.6
6	10.9	7.1	10.0
7	8.6	5.4	7.8
8	13.5	11.9	13.1
9	3.8	4.8	4.0
10+	2.4	1.6	2.2
Olefins	Regular	Premium	Wtd 75/25
4	0.9	1.5	1.1
5	3.4	5.2	3.8
6	2.0	2.9	2.2
7	1.0	0.9	1.0
Aromatics	Regular	Premium	Wtd 75/25
6	1.0	0.7	0.9
7	6.6	15.4	8.8
8	8.9	9.4	9.0
9+	16.3	14.1	15.7
			99.9%

* Unleaded fuel only.

Table 2-15. VAPOR COMPOSITION FROM SEVERAL GASOLINE SAMPLES (WEIGHT PERCENT)*

C# Paraffins	Regular	Premium	Wtd 75/25
3	0.4	----	0.3
4	38.6	31.4	36.8
5	40.7	42.5	41.2
6	8.6	6.2	8.0
7	1.8	1.0	1.6
8	1.1	1.1	1.1
Olefins	Regular	Premium	Wtd 75/25
4	3.1	7.6	4.2
5	3.7	5.1	4.0
6	0.6	2.7	1.1
Aromatics	Regular	Premium	Wtd 75/25
6	0.5	0.2	0.4
7	0.8	2.1	1.1
8	0.1	0.1	0.1
			99.9%

* Unleaded fuel only.

Table 2-16. HYDROCARBON PROPERTIES

C# Paraffins	Density, lb/gal	Heat of Combustion, Btu/gal (Net)
3	4.22	19,767
4	4.77	93,100
5	5.14	100,000
6	5.51	106,000
7	5.75	110,000
8	5.94	114,000
9	6.1	116,500
10	6.3	121,000
Olefins		
4	5.07	98,000
5	5.43	104,000
6	5.70	107,000
7	5.80	112,500
Aromatics		
6	7.37	127,270
7	7.26	126,640
8	7.27	128,000
9	7.3	129,000
10	7.3	129,000

The final factor that must be considered is the combustion efficiency of the purged vapors relative to the fuel from the vehicle fuel system (i.e., the degree to which the engine uses the vapors from the canister as if they were vaporized gasoline from the fuel system). As discussed elsewhere, EPA expects that most vehicles will have feedback control which will allow a very high combustion efficiency. The EPA's current best estimate used here is a 100 percent efficiency. However, for sensitivity a combustion efficiency of 80 percent was also evaluated.

With the information collected above, equivalent gallons of gasoline recovered by onboard systems were calculated as shown below:

$$\text{Equivalent gallons of gasoline saved} = \frac{(EF)(E_v)(VMT)0.97}{(MPG)(E_g)} \times CE$$

EF = Refueling emission rate (5.9 g/gal)
E_v = Heat of combustion for gasoline vapors (42.5 Btu/g)*
VMT = Lifetime vehicle miles travelled (100,000 mi LDV, 120,000 mi LDT)
MPG = Fuel economy for the vehicle class and model year of interest (miles per gallon) [Section 2.7.1.c]
E_g = Heat of combustion for the liquid gasoline (113,800 Btu/gal)
CE = Combustion efficiency of purged vapors (0.8 - 1.0)

Using the fuel economies projected for LDV's and LDT's for the years 1989, 1994, and 2000, which were presented previously, and the information presented above, the gross equivalent gallons of fuel recovered for LDV's and LDT's for the model years of interest were calculated from this equation as shown below:

		1989	1994	2000
LDV	100%	8.7	8.0	7.3
	80%	7.0	6.4	5.9
LDT*	100%	13.9	13.5	12.7
	80%	11.1	10.8	10.2

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*Same for single and dual tank trucks.

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*97,900 Btu/gal ÷ 5.07 lb/gal ÷ 545 g/lb = 42.5 Btu/g.

2.7.1.3 Net fuel consumption credit. Both the weight penalty and the gross consumption credit are now expressed in terms of equivalent gallons of gasoline saved (or consumed) over the life of the vehicle. The net fuel consumption credit can now be found by simply subtracting the weight penalty from the gross consumption credit. The net, undiscounted, lifetime refueling vapor recovery credits, in gallons, for LDV's and LDT's are shown below:

	1989	1994	2000
LDV	6.6	6.0	5.5
LDT (single)	10.3	10.0	9.2
LDT (dual)	5.3	5.1	4.7
LDT Weighted Average	9.3	9.0	8.3

2.7.1.4 Dollar value of recovery credits. The dollar values of the refueling recovery credits were found using the net equivalent gallon recovery credits presented above. In order to calculate these dollar values, both the vehicle mileage accumulation rates and the time value of money must be considered. In discounting recovery credits, it is necessary to estimate the timing of vapor recovery. Since the vapor will be recovered and used as the vehicle is fueled and operated, the timing of the recovery credits can be approximated by the average rate at which a vehicle is expected to accumulate mileage.

Mileage accumulation rates for LDV's and LDT's were taken from a recently published EPA study in support of the 1988 and later model year LDT/HDE NO_x and particulate standards (I-A-105). Table 2-17 shows the average mileage accumulation and proportion of LDV mileage accumulated during each year in the vehicle's life. Table 2-18 shows the mileage accumulation for LDT_1 and LDT_2, as well as the weighted average LDT mileage accumulation. The mileage accumulation is sales weighted as 61.9 percent LDT_1 and 38.1 percent LDT_2. The sales weighting is consistent with the splits used in EPA's MOBILE3 fuel consumption model. Also shown in Table 2-18 is the proportion of LDT lifetime mileage accumulated in each year. The mileage accumulation figures shown in Tables 2-17 and 2-18 represent the average amount of mileage expected to be accumulated by a "model vehicle" during the first 20 years of use. The mileage accumulation figures reflect both changes in usage patterns over time and expected vehicle scrappage rates. Although some

Table 2-17. LDV MILEAGE ACCUMULATION

Year	Miles	Proportion of LDV Mileage Accumulation
1	14,580	0.1458
2	13,200	0.1320
3	10,870	0.1087
4	9,830	0.0983
5	8,440	0.0844
6	7,630	0.0763
7	7,070	0.0707
8	5,980	0.0598
9	4,810	0.0481
10	4,110	0.0411
11	3,490	0.0349
12	2,780	0.0278
13	1,860	0.0186
14	1,400	0.0140
15	1,080	0.0108
16	720	0.0072
17	680	0.0068
18	580	0.0058
19	550	0.0055
20	340	0.0034

Source - "Regulatory Impact Analysis, Oxides of Nitrogen Pollutant Specific Study and Summary and Analysis of Comments," U.S. EPA, OAR, OMS, March 1985.

Table 2-18. LDT MILEAGE ACCUMULATION

Year	LDT1 (miles)	LDT2 (miles)	LDT (miles)	Proportion of LDT Mileage Accumulation
1	17,394	18,352	17,759	0.1419
2	15,373	16,149	15,669	0.1252
3	13,553	14,175	13,790	0.1102
4	11,917	12,409	12,104	0.0967
5	10,447	10,831	10,593	0.0846
6	9,127	9,421	9,239	0.0738
7	7,944	8,164	8,028	0.0641
8	6,884	7,044	6,945	0.0555
9	5,937	6,048	5,979	0.0478
10	4,986	5,058	5,013	0.0400
11	4,239	4,281	4,255	0.0340
12	3,574	3,594	3,582	0.0286
13	2,983	2,987	2,985	0.0238
14	2,459	2,451	2,456	0.0196
15	1,996	1,980	1,990	0.0159
16	1,587	1,568	1,580	0.0126
17	1,226	1,206	1,218	0.0097
18	910	891	903	0.0072
19	633	617	627	0.0050
20	479	465	474	0.0038

Source - "Regulatory Impact Analysis, Oxides of Nitrogen Pollutant Specific Study and Summary and Analysis of Comments," U.S. EPA, OAR, OMS, March 1985.

vehicles may survive past the 20th year, the total mileage accumulation is negligible.

Two more pieces of information are needed to calculate the discounted dollar value of the fuel recovery credits: (1) the dollar value to the vehicle operator of the fuel recovered and (2) the appropriate discount rate. The first piece of information needed is an estimate of the price of a gallon of gasoline. Gasoline prices include the wholesale price for the fuel itself, profit/overhead, and taxes. In terms of the costs to society, the fuel tax can be considered a transfer payment, so EPA has decided not to include taxes on gasoline in the recovery credit gasoline price. Therefore, the March 1985 gasoline price of $1.20/gallon (I-F-133) was reduced by $0.22/gallon (consumption-weighted Federal and average State taxes) (I-B-23) to result in a recovery credit gasoline price of $0.98/gallon. The discount rate used in this analysis is the standard EPA discount rate of 10 percent per annum.

Given the total amount of fuel recovered, the timing of that recovery, the recovery credit gasoline price and the discount rate, it is a simple matter to calculate the discounted dollar value of the recovery credits. The calculation for LDV's is described below and summarized in Table 2-19. Table 2-20 shows the LDT calculations.

The first step was to calculate the total amount of fuel recovered during each year of the vehicle life. This was done by multiplying the fractional mileage for each year of life by the total equivalent gallons of fuel recovered (calculated previously). Then the gallons recovered during each year were multiplied by the recovery credit gasoline price, $0.98/gallon. Finally, the dollar value of the fuel recovered for each year was discounted at 10 percent per annum back to the beginning of year one, assuming the credit was received at mid-year.

The total discounted dollar values of the recovery credits are shown below:

Refueling Vapor Recovery Credits - 1984 Dollars

	LDV	LDT (single tank)	LDT (dual tank)
1989-1993	4.26	6.50	3.35
1994-1999	3.85	6.31	3.22
2000 +	3.53	5.93	3.09

Table 2-19. CALCULATION OF NPV OF RECOVERY CREDITS -- LDV, 1989

	A	B	C	D
Year	Fraction of Fuel Recovered During Given Year[a]	Dollar Value of Fuel Recovered in Given Year (A x 6.6 Gal/ Life x $0.98/gal)	Discount Factor	Discounted Dollar Value of Fuel Recovered (B x C)
1	0.1458	0.943	0.953	0.899
2	0.1320	0.854	0.867	0.740
3	0.1087	0.703	0.788	0.554
4	0.0983	0.636	0.716	0.455
5	0.0844	0.546	0.651	0.355
6	0.0763	0.494	0.592	0.292
7	0.0707	0.457	0.538	0.271
8	0.0598	0.387	0.489	0.189
9	0.0481	0.311	0.445	0.138
10	0.0411	0.266	0.404	0.107
11	0.0349	0.226	0.368	0.083
12	0.0278	0.180	0.334	0.060
13	0.0186	0.120	0.304	0.036
14	0.0140	0.091	0.276	0.025
15	0.0108	0.070	0.251	0.018
16	0.0072	0.047	0.228	0.011
17	0.0068	0.044	0.208	.009
18	0.0058	0.038	0.189	.007
19	0.0055	0.036	0.171	.006
20	0.0034	0.022	0.156	.003
Net Present Value at beginning of year 1, assuming credit comes at midpoint in year				$4.24

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[a] Taken from Table 2-17 - column labeled "Proportion of LDV Mileage Accumulation."

Table 2-20. CALCULATION OF NPV OF RECOVERY CREDITS -- LDT, 1989

	A	B	C	D
Year	Fraction of Fuel Recovered During Given Year[a]	Dollar Value of Fuel Recovered in Given Year (A*0.10.3*0.98)	Discount Factor	Discounted Dollar Value of Fuel Recovered (B*C)
1	0.1419	1.43	0.953	1.36
2	0.1252	1.26	0.867	1.09
3	0.1102	1.11	0.788	0.87
4	0.0967	0.98	0.716	0.70
5	0.0846	0.85	0.651	0.55
6	0.0738	0.74	0.592	0.44
7	0.0641	0.65	0.538	0.35
8	0.0555	0.56	0.489	0.27
9	0.0478	0.48	0.445	0.21
10	0.0400	0.40	0.404	0.16
11	0.0340	0.34	0.368	0.13
12	0.0286	0.29	0.334	0.10
13	0.0238	0.24	0.304	0.07
14	0.0196	0.20	0.276	0.06
15	0.0159	0.16	0.251	0.04
16	0.0126	0.13	0.228	0.03
17	0.0097	0.10	0.208	0.02
18	0.0072	0.07	0.189	0.01
19	0.0050	0.50	0.171	0.01
20	0.0038	0.04	0.156	0.01
Total NPV of Fuel Recovered				$6.50

[a] From Table 2-18 - column labeled "Proportion of LDT Mileage Accumulation.

2.7.2 Recovery Credits for Heavy-Duty Vehicles

As is the case for light-duty trucks (LDT's), EPA expects that on the average, the addition of onboard controls to heavy-duty gasoline vehicles (HDGV's) would result in a net improvement in fuel economy. The net improvement in fuel economy is the difference between a gross reduction in fuel consumption brought about by the combustion of fuel vapors previously lost to the atmosphere, and an increase in fuel consumption resulting from the added weight of the onboard system. The methodology used to calculate the estimated change in fuel consumption resulting from the addition of onboard controls to heavy-duty vehicles is virtually identical to that used previously in this section for light-duty vehicles. Therefore, the methodology used for the calculation will only be outlined here. The reader should refer to the portion of this section on LDV's and LDT's (Section 2.7.1) for a more detailed description. As in the heavy-duty vehicle cost analysis, it has been assumed that all HDGV's fall into one of two weight classes: Class IIb (8,501 to 10,000 lb) or Class VI (19,501 to 26,000 lb). This is a reasonable approach since these HDGV GVW classes represent about 85 percent of 1984 HDGV sales. Therefore, recovery credits were calculated only for vehicles representing these two classes.

2.7.2.1 Weight penalty. Four pieces of information are needed to calculate the increase in fuel consumption, or weight penalty caused by the added weight of the system. These are: 1) average vehicle weight, 2) average fuel economy, 3) average control system weight, and 4) sensitivity of fuel economy to changes in vehicle weight.

a. Average Vehicle Weights

It was assumed that the average weight of the trucks in each of these classes fall at or near the midpoint of the weight class range. The average weights of the trucks in Class IIb and Class VI were assumed to be 9,250 and 22,500 pounds, respectively.

b. Fuel Economy

Vehicle fuel economy estimates were taken from the MOBILE3 fuel consumption model (I-A-99). The fuel economy projections are a function of the model year and weight class of the vehicle. Table 2-21 shows the HDGV fuel economy estimates used in this analysis.

Table 2-21. FUEL ECONOMY PROJECTIONS FOR HDGV'S (MPG)

	Vehicle Weight Class	
Model Year	IIb	VI
1989	11.16	6.07
1994	11.53	6.17
2000	11.98	6.31

c. Average Control System Weights

Control system weights vary with the amount of activated carbon needed for refueling vapor storage. Necessary carbon bed size, in turn, is a function of vehicle fuel tank volume. Fuel tank sizes were estimated to be 20 gallons for Class IIb trucks (40 gallons dual) and 30 gallons for Class VI trucks (80 gallons dual). As discussed in the onboard system cost analysis, dual tank usage rates of 20 percent and 15 percent were used for the Class IIb and Class VI truck fleets, respectively. Control system weight estimates are based on essentially the same set of data as used in the light-duty analysis, and a detailed explanation of the derivation is not presented here. Control system weight estimates are shown in Table 2-22.

d. Sensitivity of Fuel Economy to Vehicle Weight

There are no readily available figures which specifically relate changes in average vehicle weight to changes in fuel economy for HDGV's. Some work has been done in this area, however, and this work suggests that the fuel economy of heavy-duty vehicles is less sensitive to changes in vehicle weight than is the fuel economy of LDT's. Therefore, the LDT sensitivity value was used in the HDGV analysis, in an attempt to be conservative in evaluating the effects of the weight penalty and provide a conservative estimate of the recovery credit. Actually, on a sales weighted basis, about 80 percent of HDGV's are in Class IIb; those vehicles are similar to LDT's in many ways (drivetrain, body design, etc.). Thus, their fuel/weight sensitivity would also be similar. The sensitivity factor used is -0.402 (percent change in fuel economy per percent change in vehicle weight).

e. Calculation of Weight Penalties

Table 2-23 presents samples of the calculation of the penalties in fuel economy associated with the added weight of onboard control systems. For a more complete explanation of the calculation, the reader should refer to the light-duty section. The weight penalty estimates are summarized in Table 2-24.

2.7.2.2 Gross fuel consumption credit. The gross fuel consumption benefit was found using the following information: 1) the uncontrolled refueling emission rate, 2) the theoretical control efficiency of onboard systems, 3) the energy content of typical gasoline expressed on a

Table 2-22. HDGV CONTROL SYSTEM WEIGHT ESTIMATES* (lbs)

Vehicle Class	Single Tank	Dual Tank
IIb	5.0	13.1
VI	5.9	19.0

*Incremental to weight of evaporative emission control system components for system certified with 11.5 psi RVP fuel.

Table 2-23. SAMPLE CALCULATION OF WEIGHT PENALTIES

	Class IIb		Class VI	
Fuel tank configuration	S* (80%)	D** (20%)	S* (85%)	D** (15%)
Average incremental control system weight (lb)	5.0	13.1	5.9	19.0
Average vehicle weight (lb)	9,250	9,250	22,500	22,500
Percent change in weight (%)	5.41×10^{-4}	1.42×10^{-3}	2.62×10^{-4}	8.44×10^{-4}
Sensitivity Factor (dimensionless)	-0.402	-0.402	-0.402	-0.402
Percent change in fuel economy (%)	2.17×10^{-4}	5.69×10^{-4}	1.05×10^{-4}	3.39×10^{-4}
1989 projected fuel economy (mpg)	11.16	11.16	6.07	6.07
Projected average lifetime mileage (miles)	110,000	110,000	110,000	110,000
Lifetime fuel consumption (gallons)	9,857	9,857	18,122	18,122
Lifetime weight penalty (gallons)	2.1	5.6	1.9	6.1

*Single fuel tank.
**Dual tanks.

Table 2-24. WEIGHT PENALTY ESTIMATES (gallons/lifetime)
(HDGV's)

		Year	
	1989	1994	2000
Class IIb - Single tank (80%)	2.1	2.1	2.0
Dual tanks (20%)	5.6	5.4	5.3
Class VI - Single tank (85%)	1.9	1.9	1.9
Dual tanks (15%)	6.2	6.0	6.0

volume basis (Btu/gal), 4) the energy content of refueling vapors expressed on a weight basis (Btu/lb), and 5) a factor to reflect the engine's efficiency in burning purged hydrocarbons relative to its ability to burn fuel delivered from the fuel tank.

Ideally, the uncontrolled emission rate used in this calculation would be based on the results of a series of refuelings performed on heavy-duty vehicles. No data of this nature were available to EPA at the time of this analysis. Therefore, the refueling emission rate used in the calculation is that used in the LDV and LDT calculations, approximately 5.9 grams/gallon. As previously discussed, the theoretical control efficiency of onboard control systems has been shown to fall between 97 and 100 percent. Although these figures are based on tests performed on light-duty vehicles, there is no reason to believe that systems for HDGV's would be any less efficient. As was done in the light-duty analysis, the conservative end of the efficiency range, 97 percent, was used. The energy content and density of a "typical" unleaded fuel and its vapor were estimated in the light-duty analysis, and the calculation will not be repeated here. (While some HDGV's may still be certified for leaded fuel in the 1990's, refueling vapor from "leaded" fuel will be similar to "unleaded" fuel due to lead phase-down requirements.) The energy content and density of the liquid were estimated to be 113,800 Btu/gal and 6.13 lb/gal, respectively. The vapor associated with this fuel was estimated to have an energy content of 97,900 Btu/lb and a density (in condensed form) of 5.07 lb/gal.

The final factor used in the calculation of the gross refueling recovery credits is included to reflect the fact that the truck engine may not burn purged vapors with the same efficiency that it uses liquid fuel sent from the fuel tank. Depending on the level of sophistication of a vehicle's fuel system, EPA estimates that the relative combustion efficiency of the purged vapors will fall between 0.6 and 1.0. The gross recovery credits are calculated here using both the low and high ends of the efficiency ranges, since the credit is expected to fall between these values. However, a value of 1.0 was carried through in further calculations. The value of 1.0 was chosen rather than a lower figure for two reasons. First, there is currently a trend toward the use of feedback controlled fuel injection systems for HDGV's, which should result in improved fuel metering. Second, the new requirement that the refueling/evaporative emission canister(s) be purged during exhaust emission testing will force the manufacturers to design control systems which deal efficiently with purged vapors.

The equation used in the calculation of the gross refueling recovery credits is shown below:

Equivalent gallons of gasoline saved =

$$\frac{(EF)(Ev)(\varepsilon)(CE)(VMT)}{MPG\ (E_g)}$$

where:

EF = refueling emission rate (5.9 g/gal)
E_v = Heat of combustion for gasoline vapors (42.5 Btu/g)
ε = Theoretical efficiency of onboard control systems (0.97)
CE = Relative combustion efficiency of purged vapors (0.6-1.0)
VMT = Lifetime vehicle miles traveled (110,000 mi)
MPG = fuel economy for the vehicle class and modelyear of interest (miles per gallon)
E_g = Heat of combustion for liquid gasoline (113,800 Btu/gal)

Table 2-25 shows the estimated gross refueling recovery credits for heavy-duty vehicles.

2.7.2.3 Net fuel consumption credit. The final step in the calculation of the net fuel consumption benefit associated with the addition of onboard control systems is to subtract the weight penalty effects from the gross fuel consumption credits. Table 2-26 shows the net fuel consumption credits for HDGV's in gallons. Table 2-27 shows an example calculation of the discounted dollar values of the gross recovery credits. The dollar values of the recovery credits are summarized in Table 2-28.

2.8 ENFORCEMENT REQUIREMENTS

All of the six commenters who submitted comments on this issue felt that onboard refueling control would require more enforcement, and consequently would incur greater enforcement costs, than the Regulatory Strategies Document estimated would be necessary.

Comment: Several commenters felt that existing enforcement measures would not be adequate to ensure compliance. Some of these commenters stated that canister tampering would not be checked on most I/M inspec-

Table 2-25. GROSS REFUELING RECOVERY CREDITS FOR HDGV's
(gallons)

	Relative Combustion Efficiency	1989	1994	2000
Class IIb	100%	21.2	20.4	20.0
	60%	12.2	12.2	12.0
Class VI	100%	38.8	38.1	37.9
	60%	23.3	22.9	22.7

Table 2-26. NET FUEL CONSUMPTION CREDIT FOR HDGV's (gallons)

	Year		
	1989	1994	2000
Class IIb	18.3	17.6	17.3
Class VI	36.2	35.6	35.4
Weighted Average	22.8	22.1	21.8

Table 2-27. SAMPLE CALCULATION OF DISCOUNTED RECOVERY CREDITS ($)
(All HDGV's, 1989)

	A	B	C	
Year	Fraction of Fuel Recovered During Year*	Dollar Value of Fuel Recovered in Year (A x 22.8) Gal/Life x $0.98/Gal)	Discount Factor	Discounted Value of Fuel Recovered (BxC)
1	0.1415	3.162	0.953	3.013
2	0.1274	2.847	0.867	2.468
3	0.1146	2.561	0.788	2.018
4	0.0998	2.230	0.716	1.597
5	0.0904	2.020	0.651	1.315
6	0.0745	1.665	0.592	0.986
7	0.0641	1.432	0.538	0.770
8	0.0549	1.227	0.489	0.600
9	0.0469	1.048	0.445	0.466
10	0.0394	0.880	0.404	0.355
11	0.0324	0.724	0.368	0.266
12	0.0269	0.601	0.334	0.201
13	0.0219	0.489	0.304	0.149
14	0.0178	0.398	0.276	0.110
15	0.0152	0.340	0.251	0.085
16	0.0113	0.252	0.228	0.058
17	0.0089	0.199	0.208	0.041
18	0.0068	0.152	0.189	0.029
19	0.0047	0.105	0.171	0.018
20	0.0031	0.069	0.156	0.011
				$ 14.56

*Source: I-A-105.

Table 2-28. NET DISCOUNTED RECOVERY CREDITS ($)
(ALL HDGV's)

	1989	1994	2000
Class IIb	11.70	11.20	11.00
Class VI	23.10	22.70	22.60
Weighted Average	14.50	14.10	13.90

*Weighted assuming 75 percent Class IIb and 25 percent Class VI.

tions and others maintained that even if canisters and associated systems were subject to such inspections, it would be very difficult to verify compliance or detect tampering (I-H-2, I-H-57, I-H-58, I-H-101). One commenter stated that the kind of "spot inspections" (presumably referring to tampering surveys) described in the July 1984 EPA analysis would not be as extensive or effective as the field inspections already in place for Stage II. The commenter therefore questioned the disparity between the projected efficiency of Stage II with no enforcement and onboard with tampering (I-H-57). One commenter maintained that assembly line testing would be required on every vehicle for safety reasons (i.e., to check for backpressure and leaks) (I-H-118). Finally, two commenters stated that the onboard enforcement costs presented in the 1984 analysis were too low (I-H-90, I-H-101).

Response: Canisters are not now inspected during the course of I/M inspections because current tampering surveys do not indicate a strong need for such inspections. The July 1984 analysis originally included fillpipe tampering as a source of diminished onboard control efficiency. However, EPA now expects that many manufacturers will utilize liquid seals rather than mechanical seals in the fillneck, so removal of the lead restrictor in the fillpipe would have no effect on onboard efficiency. Also, as was mentioned previously, tampering rates are expected to diminish as the unleaded fuel price differential drops as has been the recent trend. That being the case, canister tampering remains the only potentially significant source of diminished onboard efficiency. The 1985 NEIC tampering survey indicated average canister tampering rates of 2.67 percent for LDV's and 3.29 percent for LDT's. The low canister tampering rates determined by the surveys indicate to EPA that tampering would not present a significant problem if onboard systems were used to control refueling emissions.

In the event that I/M inspections of onboard systems should prove to be necessary at some future time, EPA also does not believe that identification of tampering would prove to be particularly difficult. Tampering is unlikely to be a difficult-to-identify act such as hose splitting, but would typically take the form of canister and/or hose removal or cutting of hoses. This type of tampering would be readily identifiable through even the most cursory of visual inspections.

Given the low tampering rates described above, EPA does not find the disparity between the projected onboard and Stage II efficiencies under minimal enforcement scenarios unreasonable. Rather, it seems indicative that onboard is not particularly dependent on rigorous field enforcement measures as appears to be the case with Stage I and Stage II systems. If onboard vapor recovery system in-use inspections are implemented in the future, both the costs and benefits would have to be included in this analysis. In addition, since either fully or partially integrated refueling/evaporative systems are expected, the costs would either have to be shared between refueling and evaporative emissions or the benefits from evaporative control improvements included in this analysis.

While some selective assembly line testing of onboard systems or components may be conducted by vehicle assemblers or component manufacturers, this would not be conducted for every vehicle system or component. This has never been the practice for any emission control or safety system and there is no reason it would be required for onboard controls. Manufacturing techniques and controls are sophisticated enough to provide assemblers and component manufacturers statistical confidence in their performance. In addition, onboard control systems are relatively simple and any likely system failures can be designed out with ease.

The costs estimated by EPA were Agency costs for certification and Selective Enforcement Audits. This estimate is not low or misleading, however, because no other enforcement costs are likely to be incurred. As explained above, EPA does not anticipate that canisters and hoses would routinely be checked on I/M inspections. Nor does the Agency foresee any need for performance testing. Thus, no additional enforcement costs are likely to be incurred.

2.9 REFERENCES (Comment letters are not repeated here. See Chapter 1, Table 1-1, for a complete list of comment letters.)

I-A-29 Summary and Analysis of Comments on the Notice of Proposed Rulemaking for the Control of Light-Duty Diesel Particulate Emissions from 1981 and Later Model Year Vehicles, Chapter V - Economic Impact. U.S. EPA. October 1979.

I-A-40 Motor Vehicle Tampering Survey - 1982, 1983 and 1984. U.S. EPA, Office of Enforcement and Legal Counsel/Air and Radiation. EPA-330/1-83-001. April 1983, July 1984 and September 1985.

I-A-55 Evaluation of Air Pollution Regulatory Strategies for Gasoline Marketing Industry, U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, and Office of Mobile Sources, EPA-450/3-84-012a, July 1984; Including Appendix A: "The Feasibility, Cost and Cost Effectiveness of Onboard Vapor Control," Glenn W. Passavant, U.S. EPA Report EPA-AASDSB-84-01, EPA, OAR, OMS, ECTD, SDSB, March 1984.

I-A-58 Northeast Corridor Regional Modeling Project - Determination of Organic Species Profiles for Gasoline Liquids and Vapors. Prepared by MRI, Kansas City, MO, for U.S. EPA, Research Triangle Park, NC. EPA-450/4-80-036a. December 1980.

I-A-66 Study of Volatility and Hydrocarbon Emissions from Motor Vehicles. U.S. EPA, Office of Mobile Sources. EPA-AA-SDSB-85-5. November 1985.

I-A-69 Refueling Emissions from Uncontrolled Vehicles. U.S. EPA, Office of Mobile Sources. EPA-AA-SDSB-85-6. 1985.

I-A-70 Tech IV Credit Model: Estimates for Emission Factors and Inspection and Maintenance Credits for 1981 and Later Vehicles for MOBILE3. U.S. EPA, Office of Mobile Sources. EPA-AA-IMG-85-6. October 1985.

I-A-71 Draft Recommended Test Procedure for the Measurement of Refueling Emissions. U.S. EPA, Office of Mobile Sources. EPA-AA-SDSB-85-5. July 1985.

I-A-73 Control of Air Pollution from New Motor Vehicles and New Motor Vehicle Engines. Federal Certification Test Results for 1984 Model Year. U.S. EPA, Office of Mobile Sources. 1984.

I-A-74 Control Characteristics of Carbon Beds for Gasoline Vapor Emissions. U.S. EPA. EPA-600/2-77-057. February 1977.

I-A-76	Refueling Test Procedures. Workshop held at Motor Vehicle Emissions Laboratory. U.S. EPA, Ann Arbor, MI. April 10, 1986.
I-A-77	"Costs of Onboard Vapor Recovery Hardware," Jack Faucett Associates and Mueller Associates for U.S. EPA, 1985.
I-A-93	"Transmittal of Onboard Test Data," Series of U.S. EPA Memoranda, William Pidgeon to Addressees, EPA, OAR, OMS, ECTD, TEB, August 27, 1985 to January 23, 1986.
I-A-97	"Cap Removal Emissions," U.S. EPA Memorandum, Gary Holladay to The Record, EPA, OAR, OMS, ECTD, SDSB, November 22, 1985.
I-A-99	Wollott, M.A. U.S. EPA and D.F. Kahlbaum, Computer Sciences, Corp. Mobile 3 Fuel Consumption Model. EPA-AA-TEB-EF-85-2. Office of Mobile Sources. U.S. EPA, Ann Arbor, MI. February 1985.
I-A-100	"Investigation of Passenger Car Refueling Losses," APTD-1453, Scott Research Laboratories for U.S. EPA, September 1972.
I-A-101	Cost Estimations for Emission Control-Related Components/Systems and Cost Methodology Description. U.S. EPA, Ann Arbor, MI. EPA-460/3-78-002, 1978. (Available in Docket A-80-18.)
I-A-104	"Light-Duty Automotive Fuel Economy ... Trends Thru 1985," Heavenrich, Murrell, Cheng, Loos, U.S. EPA. SAE Technical Paper Series #850550, 1985.
I-A-105	"Regulatory Impact Analysis, Oxides of Nitrogen Pollutant Specific Study and Summary and Analysis of Comments," U.S. EPA, OAR, OMS, March 1985.
I-A-106	"Update of EPA's Motor Vehicle Emission Control Equipment Retail Price Equivalent Calculation Formula," Jack Faucett Associates for U.S. EPA, September 4, 1985.
I-A-107	"In-Use Evaporative Canister Evaluation," U.S. EPA Report EPA-460/3-85-003, EPA, OMS, ECTD, December 1985.
I-A-108	"Additional Mini-Canister Evaluation," U.S. EPA Report, EPA-460/3-85-010, EPA, OMS, ECTD, December 1985.
I-A-109	"Evaluation of the Feasibility of Liquid Fillneck Seals," U.S. EPA Report EPA-AA-SDSB-86-03, EPA, OAR, OMS, ECTD, SDSB, December 1986.
I-A-111	"Investigation of the Need for In-Use Dispensing Rate Limits and Fuel Nozzle Geometry Standardization," U.S. EPA Report EPA-AA-SDSB-87-07, EPA, OAR, OMS, ECTD, SDSB, May 1987.
I-A-112	"Safety Implications of Onboard Vapor Recovery Systems, U.S. EPA Report EPA-AA-SDSB-87-05, EPA, OAR, OMS, ECTD, SDSB, June 1987, Final Report.

I-B-18 Memorandum from Reineman, Martin, U.S. EPA/SDSB, to Gray, Charles, U.S. EPA/ECTD. March 6, 1979. Status of In-House Refueling Loss Measurements.

I-B-19 Memorandum from Heiser, Daniel, U.S. EPA/SDSB, to Gray, Charles, U.S. EPA/ECTD. January 1984. Significance of 'Popping and Hissing' Emissions from an LDV Gasoline Tank.

I-B-20 Memorandum from Johnson, Robert, U.S. EPA/SDSB, to the Record. September 2, 1986. Cost of Crash Testing to Assure Fuel System Integrity for Onboard Systems.

I-B-21 Memorandum from Passavant, Glenn, U.S. EPA/SDSB, to Cristofaro, Alexander, U.S. EPA, Regulatory Policy Division. January 14, 1986. Fuel Consumption Sensitivity Analysis.

I-B-22 Memorandum From France, Chester, U.S. EPA/SDSB, to Wilson, Richard, U.S. EPA/OMS. July 28, 1986. Review of General Motors' Comments on Fuel Economy Impacts of Onboard Regulation.

I-B-23 Memorandum from Shedd, Steve and Robson, John, U.S. EPA/OAQPS, to Weigold, James, U.S. EPA/OAQPS. October 17, 1985. Recovery credit gasoline prices for the gasoline marketing analyses.

I-B-27 "Cost of Activated Carbon Used in Evaporative Canisters," U.S. EPA Memorandum, Daniel Heiser to The Record, EPA, OAR, OMS, ECTD, SDSB, July 10, 1984.

I-B-28 Workshop on Refueling Test Procedure held at the Motor Vehicle Emissions Laboratory on October 17, 1984.

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I-B-42 "Incremental Costs and Cost Effectiveness of Onboard Controls for HDGVs," U.S. EPA Memorandum, Robert J. Johnson to The Record, EPA, OAR, OMS, ECTD, SDSB, February 26, 1987.

I-D-46 Letter plus enclosures from Gobis, L.P., MVMA, Detroit, MI, to France, C.J., U.S. EPA/SDSB. March 7, 1985. Transmittal of graphics and list of major MVMA concerns on refueling test proposal.

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I-D-269 Draft of "Manufacturing Cost and Retail Price Equivalent of Onboard Vapor Recovery System for Gasoline Filling Vapors," Leroy H. Lindgren for the American Petroleum Institute, 1983.

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I-D-319 Memorandum, David E. Martin, Director, Automotive Safety Engineering, GM, to Barry Felrice, NHTSA, March 24, 1986.

I-F-17 On-Board Control of Vehicle Refueling Emissions Demonstration of Feasibility. American Petroleum Institute (API) Publication No. 4306. API. Washington, D.C. October 1978.

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I-F-134 "Highway Statistics 1984," U.S. DOT Report, FHWA-HP-HS-84, DOT, FHWA, 1985.

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I-H-151 "Analysis of Selected Stage II Issues for Dallas, Texas, and Philadelphia, Pennsylvania," Radian Corporation for API, July 15, 1985.

I-H-158 "Vehicle Onboard Refueling Control," American Petroleum Institute Publication No. 4424, March 1986.

3.0 STAGE II CONTROLS

3.1 STAGE II TECHNOLOGY

Comment: Several commenters stated that the recently certified Stage II equipment and nozzles have proven to be durable and reliable, and have worked well in the hands of both service station attendants and customers. The commenters felt early technical problems with Stage II nozzles used in California in the mid-1970's have been substantially reduced through debugging and redesign (I-D-56, I-D-59, I-H-2, I-H-58, I-H-99, I-H-107, I-H-127, I-H-131). Other commenters noted that the controls are thoroughly demonstrated and are being used in California and Washington, D.C., with satisfactory results (I-H-22, I-H-53, I-H-100, I-H-101, I-H-115, I-H-128). One of these commenters pointed to implementation of Stage II controls in California and Washington, D.C., and proposals to implement controls in seven other States as indicative of the confidence that can be placed in Stage II for controlling regional ozone formation (I-H-100).

A control equipment manufacturer added that, although present production nozzles work quite satisfactorily, the company has developed a new Stage II nozzle that is almost as light and small as a regular nozzle. The manufacturer indicated this low maintenance nozzle was due to be placed in service in 1985 (I-H-131).

Several commenters claimed that Stage II is not a satisfactory method of vapor recovery and that the technology is relatively experimental and unproven (I-H-1, I-H-1A4, I-H-1A28, I-H-13, I-H-52, I-H-67, I-H-84). Three commenters indicated that Stage II vapor recovery has not been endorsed by the U.S. EPA since no CTG has ever been published for Stage II (I-H-1, I-H-15, I-H-84).

Response: The Agency, in reviewing the operating experience reported with newer Stage II equipment, feels that Stage II is a technologically feasible approach to vapor emission control. In addition, the trend is toward improved, more acceptable components, as referred to by one of the commenters. To the extent that States adopt Stage II in ozone nonattainment areas, it is possible that further improvements in the systems would occur as the increased market led to further competition among manufacturers. Regardless of the improvements, Stage II equipment has the potential (real or perceived) for being less convenient to use then conventional equipment. The following sections discuss various aspects of Stage II controls.

Comment: One commenter felt that closed Stage II systems, such as the Hirt vacuum-assist system, would not suffer the degree of spit-back hazard that characterizes pressurized refueling concepts such as the Stage II balance system (I-H-74).

Response: All three types of Stage II systems, the vapor balance, hybrid, and vacuum assist, were evaluated on an equal basis with no attempt made to establish a rating of their performance. Specific information was not available on the degree of spit-back or spillage associated with each one of these Stage II systems. As a result, a comparison of the spit-back and spillage hazard of the three systems could not be made. It should be noted, however, that all three system types have been certified and are operating in California. The CARB has indicated that, while spit-back was a problem with early Stage II systems, the problem has been solved in current systems through nozzle modifications and through the use of high hang hoses and high hose retractors (I-E-53).

3.2 STAGE II DESIGN AND SAFETY CONSIDERATIONS

Comment: One commenter stated that one particular model of Stage II nozzle in current use does not latch securely to approximately 50 percent of the domestic and imported automobiles, as well as motorcycles, gas cans, vans, trucks, and many off-the-road vehicles. The commenter also stated there is no uniformity among automobile manufacturers as to the fillpipe location and opening, unleaded inserts are not always correctly installed, and it is difficult to determine whether the tank is really full due to the variable shutoff sensitivity of nozzles. This commenter also indicated that during refueling, some fuel can recycle back through the vapor recovery hose. The commenter stated that in order to purge the aboveground system of gasoline (as reportedly recommended by the manufacturer), the fuel is often allowed to drain to the pavement, which allows vapors to escape and exposes the employee (I-H-18). A number of commenters based their opposition to Stage II on the problems and expense actually experienced in California and the District of Columbia (I-H-1A4, I-H-1A22, I-H-1A27, I-H-18, I-H-51, I-H-84).

Response: Stage II controls are currently handling about 9 percent of the nation's gasoline in California and the District of Columbia with generally satisfactory results. Stage II systems in some areas of California have been installed for over 10 years and have been demonstrated. Equipment manufacturers claim that preliminary technical problems with Stage II have been reduced by design improvements, and that customer acceptance problems also are being reduced.

The California Air Resources Board (CARB) has analyzed incidents of spillage and other types of gasoline liquid loss due to incompatibility between nozzles and vehicle fillpipes. Legislation, passed in California in 1976, requires vehicle manufacturers to design uniform vehicle fillpipes to allow a tight seal and to accept specified gasoline dispensing rates without gasoline spillage and spit-back, and without shutting off prematurely. In response to reports of gasoline recirculation in Stage II systems, California issued a new standard requiring vapor recovery nozzles to have parallel shutoff mechanisms (a shutoff activated by the liquid level in the fillneck and a shutoff activated by sensing liquid in the vapor hose). Also, high-retractor twin and coaxial hose or high-hang coaxial hose configurations have been found to allow a gasoline dispensing rate as high as 10 gallons per minute. This increase in dispensing rate may improve the reliability of shutoff mechanisms, thus reducing the potential for gasoline recirculation. It is asserted that this higher rate should not result in increased incidences of spillage and spit-back of gasoline during refueling (I-F-78).

Comment: Four commenters stated the belief that Stage II systems present a fire/safety problem (I-H-1, I-H-1A3, I-H-18, I-H-84). One of the commenters said that the D.C. Fire Marshal had offered testimony, at a roundtable discussion held by the D.C. City Council Transportation Committee, that Stage II vapor recovery nozzles are unsafe (I-H-18). Another commenter referred to a 1981 study by Radian Corporation for the Texas Air Control Board, which claimed that the vacuum assist Stage II system has potential safety hazards with explosive conditions in piping and vehicle tanks, along with leakage of vapors from recovery lines and units (I-H-84). One manufacturer of Stage II systems commented that vacuum assist is an effective fire hazard reduction technique (I-H-129).

Response: In response to these comments, the California Air Resources Board (CARB) was contacted to determine whether there had been any incidents of fire or explosion related to Stage II systems in California or whether CARB considered the systems to be unsafe in any way (I-E-54). A CARB representative related that the systems in use in California are considered safe, and no incidents of fire or explosion have occurred. Refueling is actually considered safer with Stage II in place than without it because fumes around the islands are reduced and the storage tank vapor spaces are kept saturated (above the explosive range). The State Fire Marshal approves all systems as safe before they are certified for use.

3.3 STAGE II CONTROL EFFICIENCY*

Comment: A number of commenters thought EPA's assumed Stage II in-use efficiency was too low (I-H-2, I-H-57, I-H-58, I-H-74, I-H-82, I-H-93, I-H-101, I-H-114, I-H-127). Two of these commenters referred to tests performed on Stage II systems in customer service in California (I-H-2, I-H-127). Other commenters state that the experience of the South Coast Air Quality Management District (SCAQMD) of California is that Stage II equipment attains more than 95 percent efficiency the majority of the time, and is taken out of service if there is a problem (I-H-57, I-H-58). Stage II efficiency estimates are claimed to be too low because they were based on the initial California program administration and on data for first-generation equipment that is now obsolete and illegal to install (I-H-82, I-H-114). The 56 percent efficiency cited by EPA assumes that there is no field enforcement. A commenter thinks this is unrealistic since an in-use efficiency of greater than 80 percent can be insured with annual inspections (I-H-118). Another cites results from the SCAQMD that show a 98.6 percent efficiency at the nozzle/fillneck interface for a Hirt system using a Rudolph nozzle (I-H-74).

Two commenters thought the Stage II in-use efficiency assumed in the evaluation was too high (I-H-84, I-H-120). One of them pointed out that a July 1981 study by Radian Corporation for the Texas Air Control Board estimated that the balance system would provide 85 to 88 percent control with a standard nozzle, compared with 93 to 95 percent with a no-seal, no-flow nozzle; and the vacuum system would achieve

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*1984 Federal Register topic.

88 to 90 percent with a standard nozzle and up to 97 percent with a no-seal, no-flow nozzle. This commenter mentioned that CARB had estimated that Stage II equipment defects may reduce California's 130 tons per day of emission reductions by 3 to 16 percent (I-H-84). Another commenter referred to a report to the California Legislature that showed actual in-use efficiencies to be only 80 to 92 percent. The commenter felt that, although enforcement data from actual experience in California was used, California may not provide a useful "average" from which to predict nationwide in-use efficiencies for Stage II, because it assumes a vigorous, costly, and difficult enforcement program (I-H-120). Four commenters thought Stage II would cause serious public acceptance problems that would drastically offset in-use effectiveness. In fact, the commenters did not consider it to be certain that an 86 percent efficiency level of compliance could be obtained for any feasible enforcement effort (I-H-102, I-H-108, I-H-119, I-H-120).

Response: All three types of Stage II systems were assigned a theoretical (certification-level) control efficiency of 95 percent (Table 3-1 of the strategies evaluation document Reference 1 in Chapter 1). In-use efficiencies in the July 1984 analysis were determined based on various assumed frequencies of enforcement, i.e., facility inspections to determine the need for and to enforce necessary repairs. The balance type system was estimated to have an in-use efficiency range of 54 percent (minimum enforcement) to 86 percent (annual enforcement), the hybrid system a range of 62 to 88 percent, and the vacuum assist system a range of 55 to 86 percent. The weighted average for all types of systems ranged from 56 to 86 percent.

The EPA evaluated new data in an effort to update the in-use efficiency estimates (see Appendix A of the Vol. I RIA referenced in Chapter 1). The Agency examined a recent report on inspection of all Stage II service station installations in the Washington, D.C., area, and revisions were subsequently made to the estimates for the frequency and types of defects affecting Stage II systems. Using this information, the Agency's estimate for the lower end of the Stage II efficiency range was adjusted from 56 to 62 percent.

The EPA also evaluated the latest California Air Resources Board data, which were presented in the 1983 Report to the Legislature (I-F-78). However, the data were insufficient to differentiate between first-based solely on third-generation systems could not be estimated. Additional data were obtained from randomly selected service stations in the Bay Area of California, which indicated an in-use efficiency of 90 to 92 percent; however, the data were considered inadequate to update the in-use figure for the entire State of California. Therefore, the upper end of the in-use efficiency range was not changed from the previously used value of 86 percent. Enforcement costs associated with this upper efficiency value were calculated and included in the costs evaluated in the Volume I RIA for Stage II regulatory strategies.

Comment: One commenter claimed that spills and leaks reduce the effectiveness of Stage II (I-H-59). Several other commenters indicated that customer avoidance actions, such as topping off, would reduce the control effected by Stage II (I-H-33, I-H-40, I-H-44, I-H-68, I-H-71, I-H-76, I-H-77, I-H-78, I-H-84, I-H-85, I-H-89, I-H-96, I-H-97, I-H-102, I-H-105, I-H-106, I-H-110, I-H-121, I-H-123).

Response: It is true that spills and leaks would reduce the effectiveness of Stage II or any other vehicle refueling control system. Recent design changes implemented in California are intended to reduce the spillage and spit-back problems found in first-generation systems. Design changes include new nozzle designs, high hose retractors, and more stringent nozzle certification procedures. Customer avoidance actions also can reduce Stage II efficiency. California officials contacted advise that, when undertaking Stage II, an active initial consumer education program be initiated at an early stage in order to limit such problems.

3.4 COSTS OF STAGE II*

Comment: Several commenters felt that the cost estimates for Stage II controls used in the EPA study were too low, since they were based on California data from 1978. Some of these commenters stated that the costs in 1978 were based on first-generation systems, while current 2nd- and 3rd-generation costs are much higher (I-H-20, I-H-34, I-H-37, I-H-44, I-H-62, I-H-66, I-H-68, I-H-89, I-H-91, I-H-108, I-H-109, I-H-110, I-H-126). One of the commenters believed that the Stage II costs developed by EPA severely underestimate the costs actually experienced with real systems, indicating that annualized cost estimates made by CARB are about

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57 percent greater than EPA's estimates (I-H-109). Two other commenters said that a recent American Petroleum Institute (API) cost study (I-F-98) contained data on the actual construction and maintenance costs of Stage II, showing that the costs derived from 1978 California data are unreasonably low (I-H-20, I-H-34). One commenter noted that EPA's Stage II cost analysis relied heavily on the Luken report (I-A-22). The commenter felt the Mueller comparison of API, EPA, and Lundgren cost estimates, and, in particular, API's analysis of CARB data showed that Stage II is substantially more expensive than the EPA or Luken estimates (I-H-120).

Several commenters cited various Stage II costs from studies by the Petroleum Marketers Association of America (PMAA), Sierra Research Corporation, API, and individual personal research and experience. Many of the commenters referred to the study performed by the PMAA that estimated the cost of Stage II controls at $16,000 for each service station (I-H-19, I-H-33, I-H-54, I-H-56, I-H-64, I-H-71, I-H-77, I-H-79, I-H-80, I-H-85, I-H-96, I-H-97, I-H-105, I-H-106, I-H-110, I-H-121, I-H-123). Three other commenters referred to the January 1984 API study which estimates that for a Stage II balance system the cost ranges from $7,740 for a three-nozzle to $23,780 for an 18-nozzle outlet, and for a Stage II vacuum assist would range from $12,860 for a three-nozzle outlet to $29,770 for a larger outlet (I-H-24, I-H-84, I-H-91). Other commenters indicated that the cost to the average marketer would range between $1,200 and $2,000 per hose on an installation of Stage II. The commenter's estimates reportedly were based on personal research and on actual experience in California and Washington, D.C. (I-H-1, I-H-15, I-H-1A17, I-H-1A24, I-H-1A30, I-H-102). Several other commenters stated that the necessary capital cost for compliance with Stage II would mean an investment of approximately $10,000 to $22,000 per service station (I-H-15, I-H-1A13, I-H-1A20, I-H-1A25, I-H-87, I-H-108, I-H-130). One of these commenters supplied a $70.1 million total cost figure for Stage II equipment within an 8-county area of Illinois based on an average cost for Stage II equipment per station of $15,000 (I-H-15). One commenter, a manufacturer of control equipment, stated that the costs for Stage II systems presented in Table 7-15 of the EPA report were much different than his experience indicated, saying that typical installation costs are $1,800 per station (I-H-129).

This commenter and two others (I-H-108, I-H-119) pointed out that EPA's Stage II cost estimates, on a per-nozzle basis, increase after nine nozzles and that such a result is contrary to practical experience where, once certain expenses are fixed, the marginal costs of a larger system on a per-nozzle basis should be less. One commenter indicated that replacement nozzles cost hundreds of dollars apiece and that some suppliers will not handle an order of less than $500 (I-H-18).

Response: The 1984 analysis drew almost entirely upon published data to estimate Stage II costs. Costs were put on a common basis (1982 dollars) using cost indices. Under the new analysis, Stage II costs have been updated by completing a new and detailed cost analysis. Table 3-1 indicates the differences in the Stage II costs between the previous analysis and the new analysis.

Table 3-1. WEIGHTED AVERAGE STAGE II COSTS[a]
(Retrofit of Existing Stations)

	Previous Analysis		New Analysis[c]	
Model Plant[b]	Capital Cost, $	Annual Cost, $	Capital Cost, $	Annual Cost, $
1	5,700	1,400	5,700	1,300
2	6,100	1,300	7,300	1,400
3	6,600	1,300	12,200	2,500
4	9,800	1,400	16,100	3,200
5	14,800	500	23,200	3,100

[a] Weighted average - 80 percent balance systems, 15 percent hybrid systems, 5 percent vacuum assist systems.

[b] The model plant parameters are described in the Draft Vol. I RIA.

[c] Annual costs reflect annual enforcement.

Detailed information on certified systems currently used in California, manufacturers' cost data, and engineering estimates were used to develop the new Stage II cost estimates. Retail costs (with and without quantity discounts) were obtained for all hardware (i.e., nozzles, hoses, swivels, piping, etc.) from the manufacturers. Engineering estimates were used to calculate trenching and backfill costs. These cost data were used to make estimates for the installation of a

Stage II vapor recovery system at an existing facility, and also the additional cost of Stage II equipment associated with the construction of a new facility. The California data were used because these systems are currently operational and have been shown to achieve the assumed control efficiencies, and because detailed third and fourth quarter 1984 cost information was available for each of the individual components comprising each of the California-certified systems; i.e., the individual balance system, the manifolded balance system, the hybrid system, and two assist systems.

Table 3-2 presents the capital cost estimates from the new analysis for Stage II systems installed at existing or new facilities for a "typical" 35,000 gallon per month facility (Model Plant 3). The selection of a "typical" station was based upon a throughput weighted average of stations that would require controls under a nationwide Stage II regulatory strategy. Comparing the costs for this "typical" station to those provided by the commenters is difficult because the commenters supplied insufficient descriptive information (e.g., number of nozzles, system type, other costs included, etc.) for an accurate comparison to be made. A detailed accounting and cost breakdown of capital and annualized costs used in the new analysis for each type of Stage II control system is contained in Appendix B of the Vol. I RIA.

The EPA agrees that the cost per nozzle should decrease as station size increases because certain fixed costs are divided among more nozzles. The 1984 analysis reflects this trend as long as the calculations are based consistently on the upper or lower end of the nozzle range for each model plant. In the new analysis, specific nozzle quantities were attributed to each model plant in order to identify plumbing configurations. As in the original analysis, the trend of lower per-nozzle cost as the station size increases is repeated.

Table 3-2. STAGE II REVISED CAPITAL COST ESTIMATES FOR A "TYPICAL" 35,000 GALLON/MONTH SERVICE STATION ($)[a]

Type of System	Existing Facility		New Facility	
	Capital	Annual	Capital	Annual
Balance	11,900	2,470	6,540	1,740
Hybrid	12,600	2,690	6,940	1,880
Vacuum Assist	15,400	3,470	10,190	2,760
Weighted Avg.	12,200	2,550	6,780	1,810

[a] Annual costs reflect annual enforcement.

Comment: One commenter stated that any major effort to fix or replace leaking underground storage tanks could significantly lower Stage II plumbing costs if they were done at the same time. This should be considered in the final analysis (I-H-127).

Response: It is unlikely that a Stage II and an underground storage tank (UST) program would coincide. However, in the unlikely event that they would coincide, EPA analyzed the affects on Stage II installation costs (See Appendix K of the Draft Volume I, RIA). In this analysis, it was assumed that Stage II installations and UST repairs would occur simultaneously over a 5 year period. Depending on the type of UST repair required, some or all of the Stage II trenching costs could be saved. Using a conservative estimate that 35 percent of the existing tank systems leak, the analysis indicated only a small savings (less than 6 percent) in the Stage II costs.

Comment: The same commenter felt that the cost analysis should include higher gasoline consumption, greater emissions controlled, and different exemption levels. This commenter estimated that incorporating these changes would decrease nationwide NPV costs by 27 percent and would yield a Stage II cost effectiveness of $442/Mg (I-H-127). This commenter and one other also felt that EPA cost estimates were overstated because the Agency had projected a constant number and size distribution of facilities, whereas trends are toward fewer stations and a higher percentage of large stations (I-H-114, I-H-127).

Response: In response to comments received on the initial analysis, the Agency has incorporated several changes in its revised analysis of Stage II costs. These changes include a new projection of future gasoline consumption, a revised projection of the number of service station facilities, and an analysis of additional facility exemption levels.

The EPA MOBILE3 computer model was used to project total domestic gasoline consumption out to the year 2000. This model utilizes the best Agency estimates of changes in vehicle miles traveled, fleet miles per gallon, fleet size, dieselization, and vehicle scrappage rates. Due to the uncertainty associated with several variables, the original assumption that consumption between the years 2000 and 2020 would remain constant was retained. The model projected a 16 percent decline in total gasoline consumption between 1986 and 2000, compared to the original projection of a 23 percent decline during this period (Figure 4-2 in the 1984 evaluation document). The Draft Volume I RIA contains details on the new gasoline consumption projections.

The revised projection of service station population was based on several key assumptions: (1) the total throughput of all types of stations would decrease in proportion to the decrease in gasoline consumption; (2) the average throughput per public facility would remain constant, i.e., the number of public stations would decline; and (3) the number of private stations would remain constant, i.e., the average throughput per facility would decline. In addition, this projection also considered the trend toward larger, more cost effective facilities. In order to reflect this trend, some throughput at public stations was shifted from smaller to larger model plants. A more detailed description of the model service station projections is given in Appendix D of the Vol. I RIA. The results indicated an overall 23 percent decrease in the total station population, with a 28 percent decrease in the smallest stations and only an 11 percent decrease in the largest size stations.

Two additional service station exemption levels were examined as part of nationwide and nonattainment strategies, and included a determination of total costs. Under these strategies, all service stations having throughputs of: 1) <2,000 gal/month, or 2) <10,000 gal/month, would be exempted from Stage II control requirements. The revised cost analysis is discussed in the Vol. I RIA.

Comment: One commenter indicated that EPA's capital cost data had not been refined to the level of piping and dispenser components. As a result, the commenter felt that the shorter lifetime of the dispenser components was not reflected in the amortization calculation, and thus EPA's annual cost estimates were too low (I-H-108). Another commenter referred to EPA's assumption that Stage II systems would require replacement every 8 to 15 years, stating that in fact the life expectancy of the most expensive element (plumbing) is much longer. The commenter concluded that an inflated annual amortization charge was used in the analysis, producing unrealistically high cost estimates for these systems (I-H-114). A third commenter felt that the vacuum assist (Hirt) system amortization period should be 15 years, and not 8 years, as in the evaluation document, since this system uses the same underground piping as the balance, hybrid, and simple closed systems (I-H-74).

Response: In the 1984 analysis, no attempt was made to divide the capital costs for aboveground and underground equipment to reflect different component lives. However, in the new analysis, the capital cost data for all Stage II vapor recovery systems were re-evaluated and broken down into aboveground costs, which include the cost for dispenser components, and underground costs, which include the installation cost of an underground piping system. As a result, the capital recovery cost factor used to calculate annualized costs was based on an equipment life of 8 years for the dispenser and auxiliary equipment, and 35 years for the underground piping system. Discussions with dispenser equipment vendors and the manufacturers of the two assist systems indicated that the additional dispenser equipment needed for Stage II (retractors, flow limiters, hanger kits) and the processing unit equipment will last a minimum of 5 years, and should last up to 10 years (I-E-19, I-E-20, I-E-22, I-E-23, I-E-25, I-E-26, I-E-27). Thus, 8 years was assumed for the capital recovery calculation. Several vendors of fiberglass piping, which is often used for vapor recovery piping in California, were contacted about the expected life of fiberglass pipe used in underground systems (I-E-37, I-E-38). All vendors contacted indicated that there was no reason that the pipe should ever need replacement because of deterioration of materials. One vendor indicated that it would last at least 30 years (I-E-38). For purposes of the capital recovery calculation, the underground piping lifetime for fiberglass pipe was estimated to be 35 years.

Comment: One commenter felt that revisions to assumptions in the Stage II analysis should include: 1) prioritization of phase-in (largest stations first), 2) revision of equipment life to 20 years, and 3) quarterly inspections instead of annual (I-H-114).

Response: The Agency re-evaluated all of the assumptions made in its original analysis in light of public comments and other new information obtained since the evaluation document was issued. Prioritization of phase-in (largest stations first) would presumably lead to the fastest emission reduction by controlling the largest emitters earlier in the Stage II program. However, for the purpose of simplifying the analysis, it was assumed that all station sizes would install equipment under the phase-in schedule used in the analysis.

In the 1984 analysis, an equipment lifetime of 15 years was assumed for balance and hybrid systems and 8 years was assumed for a vacuum assist system. As indicated in the previous response, equipment lifetime was modified for all Stage II systems to 35 years for the underground fiberglass piping and 8 years for aboveground dispenser equipment.

The new analysis considers a range for the efficiency of Stage II based on various enforcement levels. The upper end of the range is based on the enforcement program used in California, which is as active as any expected in other States. The California ARB estimates that annual enforcement best represents the enforcement program in effect for the entire State of California (I-E-47). In addition, an evaluation of quarterly enforcement yielded greater emission reductions but at a much higher cost, resulting in a worse cost effectiveness than for annual enforcement. Therefore, analysis of enforcement levels beyond "annual" was not considered appropriate.

Comment: One commenter pointed out that with the stimulus of a larger market, the Stage II equipment manufacturers could develop even more effective products (than the current fourth-generation Stage II equipment) at less expense. The commenter said this cost savings was not reflected in EPA's assessment of Stage II (I-H-118).

Response: The stimulus of a larger market would most likely result in Stage II equipment vendors developing more effective and less costly equipment. However, the Agency has no way to reliably predict and quantify or project any effects that an expanded market might have on the costs and effectiveness of Stage II equipment. Therefore, for the purpose of comparing strategies, it is considered appropriate to assume current, known costs in the analysis.

Comment: One manufacturer of service station control systems stated that extensive operation proves that the Hirt VCS-200 Stage I/ Stage II system pays for itself, saying that the saleable gasoline generated and conserved by the recovered vapors can be seen through the gasoline inventory records of each station with the system. He claimed typical gasoline recoveries of 0.3 percent, or 300 gallons per month for a typical (100,000 gal/month) station. This commenter stated that 300 gallons per month is equivalent to approximately $300 per month, which provides a 3-year payoff for the controls (I-H-129).

Response: It is not the Agency's intention in this analysis to recommend or differentiate among specific brands of Stage II systems, particularly on the basis of cost or cost recovery. The gasoline recovery credit calculation for both vacuum assist systems (Hirt and Hasstech) assumed a 50 percent recovery of both displacement losses and breathing losses. This resulted in recovery credit cost savings of $200/month for a Model Plant 5 station (185,000 gal/month).

Comment: Several commenters stated that the additional cost of Stage II maintenance would add a yearly expense of $1,000 to $2,000 per location (I-H-1A13, I-H-1A24, I-H-1A30, I-H-15, I-H-65, I-H-87). One commenter indicated that additional maintenance costs would be $260 per year per pump (I-H-1). Two commenters claimed that an increase of about 1/2 cent per gallon of purchased gasoline would cover the cost of maintenance (I-H-1A4, I-H-65). A commenter felt that operation and maintenance costs would exceed EPA's estimates since the operation of Stage II systems will be a continual problem, with costs that cannot be accurately foreseen at present. Also, the commenter stated the cost to replace nozzles on hybrid and vacuum systems would be $100 per year per nozzle (I-H-24).

Response: Maintenance costs for Stage II systems have been re-evaluated. The maintenance requirements and the associated annual costs were obtained from equipment manufacturers and vendors based on their experience in existing Stage II areas. The annual maintenance costs were estimated to range from $476 for a two-nozzle balance outlet to $3,070 for a 15-nozzle outlet. The hybrid system has the highest range of annual maintenance costs, from $497 for a two-nozzle station to $3,230 for a 15-nozzle station. These maintenance cost estimates were based on several assumptions: 1) that nozzles on all systems are replaced every 2 years; 2) that the vapor hoses on all systems are replaced every 2 years; 3) that the boot/faceplate assembly on a balance system is replaced three times per year; 4) that the boot/faceplate assemblies on hybrid and assist systems are replaced twice a year; and 5) that maintenance of the processing unit on an assist system is required once a year. Further details regarding maintenance costs for each model plant and the various Stage II systems can be found in Appendix B of the Vol. I RIA. For a "typical" 6-nozzle service station, the total maintenance costs have been estimated as $1,226/yr. This is equivalent to a maintenance cost of about 0.3¢/gal. Caution should be used when attempting to compare the values from the new analysis to those provided by the commenters. A station they consider "average" may be different from the station considered by the Agency.

Comment: One commenter, referring to the 4 percent taxes and insurance annual cost item, suggested that the insurance item should be included in the analysis, but not the taxes (I-H-127).

Response: The main purpose of the cost analysis is to estimate the real resource costs of the regulatory strategies. Taxes, to the extent that they are used to pay for public services and resources that enable the firm to efficiently produce output, are payments to factors of production and, consequently, real resource costs. The tax payment included as an annual cost item represents local property tax obligations. In this case, a strong argument can be made that the value of government services provided is tied closely to the tax. For this reason, the estimated local tax obligation is included in the cost analysis.

Comment: One commenter said that the cost of Stage II nozzle replacement had been redundantly covered under routine maintenance costs in EPA's analysis, increasing apparent costs and biasing the analysis in favor of onboard controls (I-H-114).

Response: The new analysis corrects this apparent redundancy in the cost estimates for Stage II nozzle replacement. The capital cost estimates for a new system include the costs of nozzles that are an essential component of that system. Thereafter, nozzle replacements qualify as a part of normal maintenance and are included in the cost of properly maintaining the Stage II system. It is assumed that each nozzle would be replaced with a new nozzle every 2 years (same lifetime as a standard nozzle). After an 8-year period has elapsed (the estimated lifetime of the dispenser equipment), nozzles continue to be considered under maintenance costs and are not treated as capital costs in any future replacements. Appendix B of the Draft Volume I RIA discusses the revised costs and assumptions relating to Stage II system equipment.

Comment: One commenter questioned EPA's assumption that the price of gasoline will remain constant over the analysis period (until the year 2020). The commenter felt if the price of gasoline increases, as many forecasters predict, the cost effectiveness of Stage II will appear more attractive (I-H-118).

Response: Cost data for Stage II were obtained and developed on a per-facility basis for each model plant size of each source category in the gasoline marketing network. These per-facility costs were then combined with data on the number of facilities requiring control within each source category and with projections of gasoline consumption, in order to determine nationwide costs for the period 1987-2020. Onboard costs were determined using per-vehicle costs and projections on the number of new vehicle registrations for the period 1987-2020. The nationwide cost estimates for this time period were not based on a projection of an increase in the price of gasoline. In the analysis, all prices were treated uniformly, assuming constant real prices. It is true that if the price of gasoline were considered to escalate at a rate greater than inflation (i.e., the actual value was increasing), the recovery credits associated with Stage II and onboard would increase, and thereby the cost effectiveness of both systems would appear more attractive.

It should also be pointed out that if gasoline prices decrease, as they did in 1985-86, the recovery credits would decrease and the cost effectiveness would appear less attractive. Since all cost fluctuations cannot be predicted, especially over a time span as long as that evaluated in this analysis, the simplifying assumption was to assume a constant gasoline price.

Comment: Three commenters felt that recovery credits do not reduce the net cost of Stage II because the prevalent gasoline distribution practice involves forcing the vapors through Stage I equipment back into truck transports and delivering them to a terminal for disposal. The commenters concluded the gasoline marketer receives no economic benefit from the collected vapors (I-H-102, I-H-108, I-H-119).

Response: As discussed in Chapter 7, recovery credits are shown in the analysis for Stage II at service stations because vapors piped to the underground storage tanks from refueling automobiles serve to prevent evaporation and subsequent loss of stored product. Thus, the value of the product not lost through evaporation is applied toward lowering the net cost of installing and operating a Stage II system (Tables 7-12, 7-14, and 7-16 of the 1984 EPA evaluation report). As pointed out on page 7-20 of the evaluation report, and indicated in Table 7-10, no gasoline recovery cost credit for the service station owner is assumed to result from the Stage I system, since the displaced vapors in this case are piped to the delivery truck tank and do not influence the product supply controlled by the service station.

3.5 COST EFFECTIVENESS OF STAGE II

Comment: Several commenters felt that Stage II would have a considerably higher cost per unit of emission reduction than onboard (I-H-1, I-H-84, I-H-96, I-H-97, I-H-109, I-H-122, I-H-123). One presented an analysis that included the company's own estimates of the cost effectiveness of four regulatory options. The commenter indicated that the cost effectiveness of onboard controls, using the higher "extra evaporative emissions" factors, was estimated to be $530/Mg; Stage II in nonattainment areas (with "creep" to additional areas) was estimated at $1,600/Mg; and Stage II nationwide, with and without exemptions, was calculated to be $1,900/Mg and $3,700/Mg, respectively (I-H-109).

Another of the commenters felt that EPA should revise its cost effectiveness estimates, considering that nationwide Stage II would require nationwide Stage I and, thus, Stage I control cost effectiveness must also be considered (I-H-122).

Response: The EPA has re-evaluated the cost effectiveness of the regulatory strategies using revised values for per-facility costs and emission factors. For Stage II, a component-by-component cost analysis was conducted, based on actual systems currently certified in California (see Draft Volume I, RIA). In the revised analysis, EPA's calculations are based primarily on an assumed annual average RVP of 12.6 (rather than 10.0), which is more representative of the current trend in gasoline volatility. However, EPA has also analyzed the effects of a range of in-use RVP levels, as low as 9 RVP in the summer, in light of the Agency's plans to propose volatility limits. The assumed average in-use RVP of gasoline, 12.6 (projected future average), caused an increase in some emission factors of as much as 50 percent (including the factor for excess evaporative emissions) (see Draft Volume I, RIA). Increasing the emission factors increases both the emission reductions achievable by the regulatory strategies and the amount of gasoline recovery credits achievable by all control systems (thereby reducing net annualized costs). The Draft Volume I RIA contains a discussion of the revised nationwide cost analysis.

Technically, Stage II controls operate independently of Stage I controls, and neither affects the emission reduction efficiency of the other. Therefore, nationwide Stage II does not require nationwide Stage I. If Stage I were considered in conjunction with Stage II controls, the cost effectiveness of the combined strategy would be better than for Stage II alone, since the cost effectiveness of Stage I is better than that of Stage II.

Comment: One commenter pointed out that, while EPA had not drawn any firm conclusions in its analysis, the text of the evaluation report appeared to suggest that onboard vapor recovery is the preferred alternative. The commenter further stated that, on the other hand, the table on page 1-25 indicates a better cost effectiveness for Stage II. The commenter felt that this contradiction was not explained (I-H-21).

Response: In both the text and tables, the evaluation report suggests that the relative attractiveness of onboard and Stage II controls depends on a variety of assumptions; i.e., on what particular option is being considered. Exemptions, discount rates, levels of enforcement, and in-use efficiency estimates influence cost effectiveness. However, cost effectiveness is only one of many factors involved in making the decision. Other factors can include costs, emission reduction, risk reduction, energy impacts, and equitable concerns. Results and recommendations depend on these and numerous other factors. The Agency does not believe that the material presented in the evaluation report represented a contradiction. The new analysis (described in the Volume I RIA) examines additional options, and many of the results in the original analysis are superceded.

3.6 STAGE II ECONOMIC IMPACTS

Comment: Several commenters pointed out the negative economic consequences to be expected if facility exemptions from Stage II requirements were granted. One commenter cited a hearing held in December 1982, by the District of Columbia Council, at which a number of gasoline marketers presented testimony concerning customer reactions to Stage II controls. The commenter presented four instances where station owners noticed a significant drop in monthly throughput after the installation of these controls (I-H-125). This commenter and three others (I-H-92, I-H-102, I-H-137) felt that similar marketplace distortions (customer flight) can be expected if exemptions from Stage II are allowed in other areas requiring Stage II. The first commenter said that allowing exemptions would, over time, undoubtedly increase the fraction of gasoline sold without refueling emission controls; consequently, no exemptions should be allowed because of their "anti-competitive" effects.

Three commenters suggested that Stage II control requirements would create market distortions because larger retailers would have to carry the whole burden of protecting against air pollution, and might adopt otherwise inefficient marketing approaches to avoid control costs (I-D-54, I-H-108, I-H-119, I-H-120). One of the commenters said a large retailer might attempt to split his operation into two smaller exempt stations rather than maintain a single nonexempt station that operates more efficiently (I-D-54, I-H-120). The two other commenters felt that, to the extent that exemptions were granted to smaller businesses, Stage II would place an unfair burden on high volume, self-service retailers by giving them alone the job of controlling air emissions (I-H-108, I-H-119).

Two commenters pointed out that smaller retailers just above an exemption cutoff would be at a competitive disadvantage because of their greater per-unit control costs than the larger facilities. The commenters felt these facilities could face bankruptcies and unemployment (I-D-54, I-H-102, I-H-120).

One commenter stated that the majority of "major" oil company service station operators not eligible for exemptions are, in fact, small independent businessmen who lease or rent the facility from the oil company. The commenter felt, while the intent of the Clean Air Act may have been to exempt "independents," the proposed Stage II exemptions would hurt many small independent retail gasoline businesses, since they would have to bear the increased operating costs of Stage II and the probable loss of business (I-H-125). Another commenter felt that a considerable segment of small business gasoline marketers would be lost if no exemptions from Stage II based on size were granted (I-H-102).

Response: Under any control strategy where some facilities are controlled and others are not, there could be some flight of customers to uncontrolled facilities, if Stage II equipment were considered more difficult to use. To what extent this occurred would depend on the location of alternative facilities, the importance of other services offered by various facilities, and other factors.

More flight might result from the choice of exemption options based on facility size than on nonattainment strategies. Where entire population areas must install Stage II controls, the distance to non-Stage II stations generally would be greater, and the associated costs of making the trip to these facilities often would be higher, than where a smaller, exempted facility may be located on the next block.

Under size exemptions, some increase in sales for non-Stage II retailers is to be expected; however, this increase would be limited. When exempted stations gain sales, their throughputs increase. If throughputs increase sufficiently, the stations could lose their exemptions and be required to install controls.

The Agency agrees that facilities receiving exemptions would not face the cost burden associated with Stage II control. Exemptions are intended to protect smaller facilities whose ability to pay for controls may be restricted, and such exemptions would often improve the competitive position of smaller facilities with respect to larger, controlled facilities. The Agency further agrees that, under an exemption scenario, those potentially experiencing the greatest economic impact would be retailers just above the size cutoff. The net employment effects of a regulatory strategy including exemptions are unknown.

As Appendix E in the Draft Volume I, RIA indicates, the potential service station closure rate would be considerably smaller under the options including exemptions than under the no-exemption options. Also, there are several factors that would influence a firm's viability other than its business volume, such as location and local competition, sales of other items, etc. Many smaller facilities with higher per-unit costs are optimal for the smaller markets they serve, and would likely be able to pass through the control costs.

The exemption levels used in the analysis were selected to reflect the requirements of the Clean Air Act and to allow a determination of the effects of other possible exemption scenarios. For example, actual levels of exemption from Stage II could be determined for a NESHAP during further regulatory analyses examining a number of specific levels of exemption. With a CTG, or if a State chose to be more stringent than a NESHAP program, exemption levels could be prescribed by individual States for implementation in their own jurisdictions. These specific levels cannot be predicted with certainty. Whatever their eventual levels may be, the purpose of the exemptions would not be to hurt, but to provide relief to, facilities facing significant economic burden due to control costs.

Comment: Numerous commenters objected to Stage II controls on the grounds that the costs would be prohibitive and would place a great financial strain on service station owners/operators. Several claimed that these costs would probably force them to halt gasoline operations or shut down their facility(ies). Many commenters pointed out the particular burden that would be imposed on small independent dealers (I-D-55, I-H-1, I-H-1A1 to I-H-1A32, I-H-4, I-H-8, I-H-11 to I-H-17, I-H-19, I-H-20, I-H-25, I-H-26, I-H-29 to I-H-32, I-H-34 to I-H-40, I-H-44 to I-H-52, I-H-54 to I-H-56, I-H-59, I-H-61 to I-H-64, I-H-66 to I-H-71, I-H-75 to I-H-81, I-H-84 to I-H-89, I-H-137, I-H-138).

Three of the commenters felt that under Stage II requirements they would stop developing new stations and/or expanding and upgrading their existing facilities (I-H-1A8, I-H-1A17, I-H-44). Four of them stated that the cost of Stage II systems would have a serious financial impact in light of the expenses already being incurred to comply with other government regulations (I-H-1A3, I-H-1A8, I-H-30, I-H-31). Another commenter from the District of Columbia said he is forced to man his self-service operations (at additional expense) in order to prevent customer abuse of Stage II equipment (I-H-18).

Response: For some retailers, the costs associated with Stage II control will be prohibitive. The financial strain (a reflection of limited profit potential) could lead to cessation of gasoline operations for some retailers and station closure for others. However, not all stations in any given size class will fail. While there is potentially a greater burden imposed on small businesses, an examination of financial ratios for various size classes of gasoline marketing firms indicates that many small firms are at least as financially sound as their larger counterparts (Appendix E in Volume I, RIA discusses station closures in more detail).

Recently, the vehicle manufacturing and gasoline marketing industries have been subject to economic fluctuations, and reduced profitability has been evident within each. Moreover, each industry is already incurring regulatory costs. Considering this variability and the relatively modest economic impacts, there is no reason to delay further regulation until markets stabilize, especially in view of the extent of the ozone problem and the potential for hazardous exposure. There may be some problems with consumer abuse of equipment, but this would occur primarily during the transition period from familiar equipment to Stage II devices.

Comment: Two commenters believed any action by EPA that resulted in Stage II controls would result in the cost of recovering refueling emissions being borne by the gasoline marketer. The commenters felt these costs would be imposed on entities that are not the source of the emissions, since refueling vapors are emitted from the vehicle, not the retail outlet (I-H-108, I-H-119).

Response: The Agency considers owners and operators liable for the control of significant pollutant emissions arising from the operations carried out at their facilities. These operations occasionally involve equipment owned by other parties and not a permanent part of the facility. (A direct parallel can be drawn between the service station refueling operation and the loading of for-hire tank trucks at a bulk terminal. Direct responsibility for controlling emissions rests with the terminal owner or operator.)

With Stage II systems, it is true that service station owners generally bear the entire burden of purchasing, installing, and maintaining emission control equipment. However, these costs would typically be recoverable by passing them through to the customer in the form of small (less than one cent per gallon) gasoline price increases or increases in other prices at the facility. Thus, control costs would be ultimately borne by the consumers patronizing controlled facilities.

Comment: One commenter stated that EPA was not thorough in assessing the costs associated with the implementation of a Stage II regulatory strategy. The commenter felt there are other costs besides the direct costs normally associated with Stage II that were not considered. The commenter indicated that these costs include: (1) a loss of Federal tax revenues for each gallon of gasoline not consumed due to increased gasoline prices (estimated as $47 million/yr, NPV of $453 million), and (2) a decline in crude sales as gasoline demand declines with accompanying losses in tax revenues, jobs, and income. This commenter felt that EPA should consider the costs associated with an increase in the concentration of large gasoline outlets as either small- or medium-size firms leave the market as a result of Stage II (I-H-102).

Response: The reduction in government tax revenue cited by the commenter represents a gain in revenue to the private sector. These funds are not lost, but are shifted within the economy.

The loss of crude sales to the gasoline marketing sector is accounted for in the loss of gasoline sales. The value of gasoline sales lost is comprised of the value of the crude product plus the value added by each stage of the production and marketing processes. Moreover, the crude oil no longer consumed in this market has other uses and other markets, so that jobs and income will not necessarily be lost.

Increased market share for large stations does not necessarily mean increased industry concentration, which depends on the number of firms in the industry and their share of the market. The gasoline marketing industry includes numerous firms of varying sizes, and most would be able to remain in business, including many in each size class. No substantial increase in industry concentration is anticipated to occur as a result of the implementation of Stage II requirements.

Comment: One commenter felt that, due to the lower flow rate of Stage II nozzles, the labor costs to operate full service islands would increase if Stage II were required (I-H-125).

Response: According to the American Petroleum Institute (I-D-38), flow rates through current uncontrolled dispensing nozzles vary widely, depending on the number of dispensers drawing simultaneously from the same submersible pump, problems with nuisance shutoff, whether full service or self-serve, and so forth. Rates through these nozzles vary from approximately 6.5 to 12 gpm. In Stage II balance systems in California, flow rates through second-generation systems are 5 to 8 gpm, while the newly certified systems allow 10 gpm. From these figures, there appears to be no significant difference between flow rates from conventional and Stage II nozzles. Thus, there should not be any noticeable difference in the refueling times at uncontrolled and controlled facilities.

Comment: Many service station owners and operators pointed out that they operate with low profit margins and stiff competition, and several stated that the cost of Stage II would ultimately be passed on to consumers (I-H-1, I-H-1A1, I-H-1A3 to I-H-1A5, I-H-1A8, I-H-1A9, I-H-1A13, I-H-1A17, I-H-1A19 to I-H-1A21, I-H-1A26, I-H-1A27, I-H-1A29, I-H-1A30, I-H-13 to I-H-16, I-H-30, I-H-36, I-H-64, I-H-66, I-H-69, I-H-71, I-H-75, I-H-76, I-H-77, I-H-78, I-H-84, I-H-86, I-H-88, I-H-89, I-H-102, I-H-108). Several commenters indicated that Stage II costs would not be recoverable in the current market economy, and that they might be driven out of business. Three commenters indicated that even if capital were available, a facility would have to pass the cost of Stage II on to the consumer or fail economically; however, in the current market, intense competition would not permit the passing on of Stage II costs (I-D-67, I-H-102, I-H-108, I-H-119). Five commenters stated that they could not pass on Stage II costs without losing market share (I-H-1A22, I-H-1A24, I-H-14, I-H-46, I-H-49); this is especially true for independent operators (I-H-54, I-H-59). Another commenter emphasized that the competitiveness in the gasoline market leaves little profit for independents. The commenter felt the imposition of Stage II control, at a time when margins are low and when marketers are being required to replace underground tanks because of State regulations, could well cause an unprecedented number of bankruptcies for independent marketers (I-H-64). Other commenters added that the automobile industry has been able to pass on most cost increases that were necessary to enable them to do business (I-H-34, I-H-38). Another of the commenters said that his company had no after-tax profits for the past 3 years largely as a result of expenditures for Stage I installation, expenditures to adjust meters to display full price, and automobile fleet mileage standards, which have decreased gasoline consumption (I-H-1A8).

Response: It should be noted that commenters (oil companies and oil trade associations) disagree as to whether they can pass Stage II costs on to consumers in the form of higher prices. In the long run, these costs must be recovered from the consumer. If they are not recovered initially, some facilities will close, and closures will place upward pressure on gasoline prices and generate cost recovery. Predicted price increases for gasoline reflect the transfer of Stage II costs to the consumer.

A close examination of these comments indicates that the commenters are expressing control costs as current expenses and comparing them only to internal sources of funds. The Agency believes it is inappropriate to assess costs only as current expenses. Annualization of costs and amortization of equipment in terms of NPV must be considered. Furthermore, it is not sufficient to compare costs only to internally generated funds; external financing must also be considered. Many variables affect capital availability and these factors vary from firm to firm.

Evaluating the effect of controls on a particular firm is complicated by the numerous factors involved in determining investment recovery, including terms of loans, total sales, gasoline throughput, existing debts, and methods of financing. For this reason, generalizations based on a firm's ownership status are unreliable. While some facilities would be likely to close, many others of corresponding volume would remain open.

A number of gasoline marketing firms have experienced reduced profitability in recent years. While existing environmental and other control expenditures might have contributed to pressure on marketing profits, they have not been solely responsible and many enterprises continue to be profitable despite this pressure.

Comment: Several commenters asserted that negative economic effects would result from service station closures. The commenters stated these effects include: (1) a reduction in employment (I-H-1A2, I-H-1A7, I-H-1A8, I-H-1A25, I-H-25, I-H-81), (2) an end to "Mom and

Pop" operations (I-H39), (3) a reduction in automobile maintenance service availability (I-H-1A8), (4) a reduction in fuel availability that would hurt local/ State economies (I-H-29), and (5) higher consumer prices resulting from a loss of competition in the marketplace as small independents are forced to shut down (I-H-1A3, I-H-1A4, I-H-1A9, I-H-19, I-H-40, I-H-44, I-H-54, I-H-79). Another commenter felt that Stage II would have a catastrophic effect on the financial ability of Maine petroleum marketers to remain in business, especially since they are currently working on a program to monitor, replace, and/or install underground storage tanks. The commenter felt closures would reduce fuel availability, adversely affecting commerce and industry, particularly the very important Maine tourist trade (I-H-29).

Response: The EPA agrees that there can be negative economic effects stemming from potential closures of service stations subject to a Stage II requirement. A much more extensive economic analysis would be needed to fully characterize these effects; nevertheless, some general responses can be made to the comments. The net employment effects of any of the regulatory strategies are unknown. Production and installation of control equipment creates jobs, while closure of stations eliminates jobs. The extent to which these effects offset each other is not estimated in the analysis.

"Mom and Pop" establishments are smaller facilities with higher per-unit production and control costs. However, because they are small, they are the facilities most likely to be exempted from control requirements under small facility exemptions. Thus, not all such operations would be expected to close.

Automobile maintenance is not necessarily tied to gasoline marketing. If a maintenance establishment is profitable, it is likely to remain open as a maintenance establishment regardless of gasoline sales; if not, the operation might close regardless of gasoline sales.

Fuel availability should not be affected by control strategies. While there may be an impact on the number of locations of available fuel, this number will change even in the absence of additional control. In the long run, throughput will be as high as demand for gasoline at the market price requires it to be. It is unlikely that availability in an entire region, State, or city would be affected.

Competition in the marketplace is expected to be preserved. The emergence of the convenience store that sells gasoline and the continuing survival of many small facilities should guarantee prolonged competition. An overall decline in the number of facilities is not sufficient to generate market power among the numerous gasoline retailers remaining in operation.

Comment: Two commenters noted that facility operators would be forced to borrow money to pay for Stage II controls and that banks and other lending institutions are reluctant to loan money for non-income-producing equipment (I-H-103, I-H-119). Two commenters stated that capital is generally not available for nonproductive investments and, therefore, it would be difficult for many small firms to obtain loans to finance Stage II (I-H-15, I-H-81). One commenter quoted a recent survey of 39 New Jersey jobbers which disclosed that the implementation of Stage II would involve an initial expenditure of $8,712,000 (based on an API cost survey of oil companies and data supplied by equipment manufacturers). The comenter stated that many small jobbers do not internally generate sufficient funds to cover this expenditure, nor can they obtain loans since such an expenditure does not contribute to the productivity or profitability of the outlet (I-H-40).

Response: Various marketing firms will finance Stage II controls with different combinations of internally and externally generated funds. Over time, market forces will push up gasoline prices, generating internal funds. However, some firms will require some initial external financing. Although in certain circumstances availability of adequate financing may be a constraint, it should not be a major barrier to stable firms. Control equipment represents a productive investment in the sense that the lack of it would result in closure of the facility, and so it is income-producing. Profitable businesses are able to obtain outside financing for improvements to their capital since they are able to repay loans. Lending institutions should be capable of perceiving this.

Comment: One commenter stated that the Clean Air Act favors an equitable distribution of the burdens and costs of improving air quality. The commenter felt that, since a marketer using Stage II would not benefit from recovered vapors, Stage II will not provide an equitable distribution of the costs; onboard will more successfully achieve this goal (I-H-102).

Response: As discussed in a response in Chapter 7, the gasoline vapors recovered in a Stage II control system reduce or eliminate evaporation in underground storage tanks, and the subsequent loss of product that occurs through tank venting. The gasoline not lost through evaporation and venting can certainly be considered a benefit of Stage II to a marketer.

The Agency agrees that onboard would provide an equitable distribution of control costs, by placing the actual purchase and maintenance of controls in the hands of consumers. This would be accomplished when a new vehicle was purchased at a slightly higher price than it would have been without controls. Costs of Stage II controls would be similarly distributed, however, if a marketer passed through control costs in the form of higher gasoline prices. Then, under either strategy, the consumer would in the end absorb the costs. The equitability of cost distribution to the providers of the emission controls (auto manufacturers or service station owners) is less clear.

3.7 STAGE II MAINTENANCE

Comment: Several commenters stated that the cost of Stage II maintenance is prohibitive and it is often costly and difficult to detect defective equipment (I-H-1, I-H-1A4, I-H-1A13, I-H-1A14, I-H-1A15, I-H-1A23, I-H-4, I-H-8, I-H-11, I-H-14, I-H-19, I-H-31, I-H-52, I-H-54). Two other commenters cited experience in California to support this claim (I-H-59, I-H-78). One commenter from the District of Columbia said that the rubber boots on nozzles undergo excessive wear by customers, the climate, and gasoline, and can "crack, tear and rip." The commenter indicated that gasoline causes wear to many internal parts made of rubber or plastic, and some of these plastic parts are prone to breakage due to customer abuse. This commenter stated that the "permanent" band on the nozzle comes apart and causes recirculation of fuel (I-H-18). Another commenter claimed that the vacuum assist system is more complex than a balance system and is therefore more often subject to mechanical failure (I-H-84).

Response: The EPA has included estimates of maintenance costs for systems such as those currently being installed in Washington, D.C. and California in the revised cost analysis. These estimates were based on discussions with equipment manufacturers and vendor experience in existing Stage II areas. The estimates include a weighted average of appropriate maintenance costs for all the available types of systems. The vacuum assist system, being more complex with the additional burner and vacuum pump equipment, may require additional maintenance for these items. However, these systems are generally easier for the consumer to use and they are being used successfully in California.

The EPA is aware that Stage II equipment does require maintenance and periodic replacement. The equipment defects referred to by the commenters were taken into account not only in the estimate of maintenance costs, but also in estimating the actual in-use efficiency of Stage II equipment. In its 1983 report to the State Legislature (I-F-78), the California Air Resources Board pointed out that many of these equipment defects were caused by sharp objects around the vicinity of the fillpipe, abuse, normal wear, improper system maintenance, and improper system installation. The CARB has been working with equipment manufacturers based on these findings to develop more durable and reliable components that will allow a more moderate, acceptable level of maintenance.

Comment: Three commenters believe that facility operators making a good faith effort to comply with Stage II regulations would be faced with large and continuous maintenance costs on Stage II equipment that can easily be rendered ineffective, thereby exposing them to liability for violating the regulations (I-H-102, I-H-108, I-H-119).

Response: As stated in the previous response, manufacturers claim that improvements being made in the durability of system components should reduce the amount of maintenance required by facility operators, in areas where Stage II may be implemented. In California, minor maintenance failures or defects found by an inspector are tagged "out of service." The station operator is given 7 days to make the necessary repairs. Specific major defects (bellows missing, major tears, etc.) or continued failures with no effort at maintenance may be considered a violation of the regulations.

As with any equipment where the untrained general public has access (such as the regular self-service equipment now in routine use around the country), a regular maintenance program is especially necessary. Such a maintenance program should provide for the repair or replacement of Stage II components before major violations occur. The costs reflected in the analysis are "average" costs and could vary significantly from one location to another.

3.8 ENFORCEMENT OF STAGE II REQUIREMENTS

Comment: One commenter stated that it is easier to ensure proper functioning of Stage II systems in use than it is for onboard systems because it is easier to inspect 200,000 gasoline stations than 100 million motor vehicles (I-H-100).

Response: The EPA agrees that, in terms of numbers, the inspection of service stations would appear to require less effort than the inspection of every automobile. However, each vehicle will not necessarily need inspection. The EPA certification program for new vehicles goes a long way to ensure that vehicles and systems produced under a certificate function properly for the vehicles' useful lives. Moreover, there are remedies under the Act (warranty and recall) that are intended to correct those situations where a defect may exist, even without inspecting every vehicle. In addition, there are many pollution-related inspections required on current new vehicles and it is anticipated that inspection of onboard systems could be incorporated into the existing vehicle inspection program at no additional cost. Similarly, onboard systems in use would require little or no maintenance, and the effects of tampering could be determined within the existing vehicle enforcement program.

Comment: Several commenters felt that vigorous enforcement would be needed to maintain the high effectiveness of Stage II systems (I-D-54, I-D-55, I-D-57, I-D-68, I-H-35, I-H-50, I-H-68, I-H-76, I-H-109, I-H-115, I-H-124). One of them felt that the required enforcement level has been demonstrated in California and should be readily attainable in other areas of the country if EPA works with the States and the public to emphasize the public health issue (I-H-115). Another commenter thought that effective enforcement on a nationwide basis would be very difficult and, without large government involvement, may be impossible (I-H-122). Several others believed Stage II would require a regulatory agency of tremendous size to police the continual problems of these systems (I-H-1, I-H-1A4, I-H-1A14, I-H-4, I-H-37, I-H-54). One commenter felt that EPA's in-use effectiveness estimate of 86 percent for the balance system is reasonable only if strict enforcement is employed; another stated that at least annual inspections would be required (I-H-109, I-H-118).

A number of commenters also referred to the anticipated high costs of enforcing compliance (I-H-4, I-H-46, I-H-80, I-H-84, I-H-87). Two commenters mentioned that the added certification and inspection fees required for a Stage II system can be costly. One commenter referred to the 1983 API study indicating that permit fees could average $285 for a 3-hose outlet and $1,201 for an 18-hose outlet, and the cost to perform an annual inspection would be about $130 (I-H-84, I-H-87). Another commenter favored permit fees or penalty fines as a method to make a Stage II enforcement program self-supporting. The commenter noted that EPA had advocated permit fees in the past in response to requirements under Section 110 of the Clean Air Act (I-H-21).

Response: Experience in California with its Stage II program has indicated that an in-use efficiency of 86 percent can be maintained through a relatively vigorous enforcement effort. This level is being considered as the upper end of the in-use efficiency range, or best that can reasonably be expected, in the Agency's revised cost/benefit analysis of the regulatory strategies. Thus, an assumed in-use efficiency of 86 percent reflects the annual inspection enforcement scenario. Annual inspections of service stations would be relatively costly but not impossible.

Enforcement costs contribute to social costs because they represent real resource use. A system of permit fees and penalty fines shifts the burden of paying for the enforcement program from the public sector to the private sector. The cost itself is not removed. Therefore, it is necessary to consider the costs of enforcement in comparing regulatory strategies. Enforcement costs were estimated for each regulatory strategy and have been included in the final cost estimates used to compare the strategies. These costs are described in more detail in the Volume I RIA.

The fee structure for certifying and inspecting systems has not been established. Undoubtedly, each jurisdiction would set fees based on its own budget needs and the costs of administering the program. These added costs would not be expected to be a major portion of the total costs of purchasing, installing, and maintaining a Stage II system.

Comment: One commenter felt EPA's analysis should have considered the quarterly inspection scenario because this level of enforcement increases the actual Stage II efficiency by 4 percent (I-H-127). Two other commenters thought that the zero-enforcement option should not be considered by EPA as a serious option because under this strategy most of the total control costs would be incurred, while the amount of captured VOC's would be drastically reduced (I-H-108, I-H-119).

Response: Likely cost and emission reduction impacts for Stage II were determined based on actual operating systems in California and Washington, D.C. Due to the very different levels of enforcement effort that exist in these two areas, these two programs were considered to represent reasonable upper and lower limits on the enforcement levels that could be expected in future programs. In California, where at least annual inspections of Stage II installations are conducted, rather high in-use control efficiencies averaging 86 percent are observed. In Washington, D.C., on the other hand, much lower in-use efficiencies of about 62 percent are observed. While the program in Washington, D.C., does not represent a total lack of enforcement, EPA has termed it "minimal enforcement." Thus, any Stage II program instituted in the future would be likely to operate at least as efficiently as that in Washington, D.C., and probably no better than the one in California. The Agency prefers to see the most efficient control programs possible, but most enforcement activities depend on the capabilities and interest of State or local authorities.

Comment: Two commenters thought that Stage II would require an unending series of subsequent rules and regulations to cover methods of handling consumer complaints, development of operating instructions and certification procedures, requirements for inspection reports, etc. The commenters referred to the extensive rulemaking addendums that exist in California (I-H-1, I-H-84).

Response: The extensive rulemaking referred to in California, where Stage II systems have been developed and refined, indeed represents a significant quantity of material. This material has evolved over several years. Areas becoming subject to Stage II requirements in the future would not likely require such extensive developmental material. First, the work performed in California (and in Washington, D.C. and St. Louis, Missouri) could be drawn upon in forming new programs. Second, EPA would provide guidance that would also make extensive rulemaking unnecessary.

Comment: One commenter asserted that poor consumer acceptance would lead dealers to be lax in maintaining Stage II equipment, making enforcement difficult. The commenter also believed that station size exemptions would cause regulated dealers to feel unfairly treated and that the maintenance of equipment, therefore, would not carry any "moral imperative" (I-H-120). Another commenter stated that enforcement would be easy to accomplish because the vacuum assist Stage II system manufactured by his company would pay for the initial investment, maintenance, and repair of the system through the gasoline recovered (0.3 percent of throughput) (I-H-129).

Response: Exempting facilities based on the volume of their gasoline business is considered desirable because the cost of controls can represent a large proportion of a station's profits, especially for smaller stations. Certain exemption options have been analyzed in response to requirements in Section 324, which applies to possible Federal regulation. The selection of cutoff levels for State-adopted requirements would rest with the States. The Agency believes that the principle of regulatory exemptions is fair and should be applied when it is dictated by an analysis of the potential impacts.

It is not clear how consumer acceptance would affect the level of maintenance of Stage II. It seems likely that a consistent level of maintenance, whether high or low, would be practiced throughout an entire facility. The costs to enforce Stage II requirements have been considered in the strategies analysis. While the Agency prefers that an operator maintain his control equipment voluntarily, enforcement programs provide an incentive to operators to keep systems in proper operating condition.

Comment: One commenter felt that EPA's analytical approach did not fully capture the subtleties of the enforcement costs issue. The commenter remarked that government budgeting is not an entirely rational process, in that resources are not always commensurate with an agency's responsibilities or public expectations, and that EPA must consider likely future enforcement resources and possible alternative uses for those resources. The commenter further remarked that if other levels of government are being relied upon, EPA must consider whether the political will exists to allocate resources for the particular purpose for the time period required (I-H-120).

Response: The Agency recognizes the political factors involved in the allocation of scarce government resources. Because of the uncertainty of the response from area to area, EPA's analytical approach does not attempt to consider such political ramifications. However, these factors and related issues not covered in the analysis were considered by the Administrator as the regulation was developed for proposal.

Comment: One commenter stated that, unfortunately for the taxpayers, a significant proportion of the inevitably higher pump price of gasoline attributable to the cost of installing Stage II vapor recovery controls will be wasted unless those same taxpayers also pay additional taxes to finance the cost of a Stage II inspection program (I-H-94).

Response: The Agency's cost analysis for a Stage II control program included the costs associated with enforcement inspections needed to maintain a reasonable control effectiveness of the Stage II equipment. The cost for the Stage II program is reflected in the estimated gasoline price increase, and so no additional taxes or costs beyond those considered in the analysis are anticipated for this purpose.

Comment: One commenter noted that, considering current State resource constraints, it is unlikely that their State agency would be able to commit the level of enforcement resources necessary to maintain a highly effective Stage II vapor recovery control program (I-H-92).

Two commenters, from two control jurisdictions in California, discussed their experience in the enforcement of local Stage II regulations. One of these commenters indicated that the record and experiences for the South Coast Air Quality Management District, California, indicate that theirs is a very effective program. The commenter indicated that fourteen positions are budgeted, allowing maintenance inspections at least twice a year. The commenter stated that each facility that receives frequent notices of violating equipment is placed on a special inspection program. The commenter further stated the public is encouraged to provide the District, over toll-free numbers, information about maintenance or misfueling problems they have encountered. The commenter noted that the District also uses the assistance of the Department of Weights and Measures in cases such as meter leaks or malfunctions (I-H-58).

The other commenter pointed out that, due to significant improvements in equipment reliability, San Diego does only one installation inspection instead of the two mentioned in the report (unless a problem is encountered), enforcement inspections have been reduced from four to three per year for stations that sell to the public, and private Stage II facilities have been reduced to one inspection per year. The commenter noted that the most effective aspect of San Diego's program has been the initial installation test requirements measuring pressure decay, vapor flow resistance, and liquid blockage; these tests were the primary reason a State survey found that San Diego had far fewer customer and dealer complaints than other districts. The commenter also pointed out that the high-hang hose loop requirement, which keeps liquid from accumulating in the vapor return hoses in balance systems and causing premature nozzle shutoff, was a contributing factor to the low number of complaints in San Diego (I-H-90).

Response: The California experience clearly indicates that budget problems can be addressed and overcome. However, it is equally clear that the will to do so might vary from State to State. Such factors were considered by the Administrator in proposing the regulation.

3.9 SCOPE/COVERAGE OF STAGE II REQUIREMENTS

Comment: One commenter suggested that Federal action be taken to make it mandatory that controls be placed on all filling station pumps (I-H-6).

Response: From a nationwide perspective, the Agency would not require controls on all service stations since it is required to obey the limitations set forth in Section 324(a) of the Clean Air Act. This section of the Act states that any EPA regulations applicable to vapor recovery from fueling of motor vehicles at retail outlets will not apply to an outlet owned by an independent small business marketer of gasoline and having monthly sales of less than 50,000 gallons. In addition, the regulatory options that included exemptions for small service stations were considered because of the smaller emissions contribution from these stations and because the economic impacts on such stations could be excessively severe. However, States acting independently on localized situations are free to adopt lower (or no) exemptions.

Comment: A number of commenters felt that Stage II controls may represent a viable means of reducing hydrocarbon emissions in order to attain regional ozone target levels in nonattainment areas (I-D-58, I-H-99, I-H-101, I-H-128). Two of the commenters stated that such controls should be required only if the Agency can demonstrate that they are a cost-effective means of achieving those ozone targets (I-D-58, I-H-99).

Response: As discussed in the preamble to the accompanying proposal, EPA believes that onboard control is the most appropriate long-term solution to the vehicle refueling problem. Moreover, although Stage II controls could theoretically realize earlier emission reductions, the uncertainty associated with rapid implementation in many areas at the same time, coupled with the duplication in costs involved and other factors, weigh against the Agency's requiring Stage II (in addition to onboard) as an interim measure. However, where a State considers Stage II to be a reasonable and necessary measure, EPA will support the State fully in its efforts to ensure that such controls are implemented.

Comment: One commenter pointed out that the cost per unit of hydrocarbon controlled by Stage II systems is markedly different between urban areas, which represent most of the areas not in ozone attainment, and rural areas, which generally are in attainment. The commenter stated that rural service stations have low throughputs and, consequently, would have high recovery costs per unit of hydrocarbon controlled if Stage II is required (I-H-99).

Response: The Agency agrees that many rural stations would face high costs if they were covered by Stage II requirements. However, as discussed in Section 3.6, many of the smaller service stations may be exempted due to lower business volumes, if Stage II were adopted. Moreover, stations in rural areas outside of designated nonattainment areas would probably not be covered under potential SIP requirements.

Comment: One commenter remarked that Stage II has the advantage of flexibility of application, and thus could be applied on a limited or provisional basis without making a premature commitment to a particular control technology. The commenter provided an example where Stage II could be implemented only in selected areas where the need was greatest, or only at certain service stations or service station operations where the exposure was likely to be the highest (enhancing cost effectiveness). The commenter concluded that with Stage II, the lead-time necessary to make modifications would be greatly reduced (as compared to onboard controls)(I-H-93).

Response: Given the nature of the ozone problem, and the potential for hazardous exposure, EPA believes there is a clear need for control of vehicle refueling. Because refueling technologies are well understood, it is doubtful there would be need for repeated modification of the regulatory requirements whether onboard or Stage II is required. However, due to the smaller number of entities controlled under Stage II (as compared to the number of motor vehicles controlled under requirements for onboard controls), and the fact that it is easier to communicate with operators of, and effect changes on, stationary businesses than owners of motor vehicles, in concept it could be easier to modify Stage II systems in-use or apply them in a limited manner. This issue is being considered in the decisionmaking process.

3.10 CONSUMER REACTION TO STAGE II

Comment: One commenter remarked that he had used Stage II systems in California and considered them superior to onboard canisters in that they not only prevent loss of vapors, but also prevent overfilling gas tanks and the resultant spillage. The commenter thought the very act of using Stage II systems would create a safety awareness in people that a carbon canister would not (I-H-3).

Response: Both Stage II and onboard type systems are designed to prevent or reduce overfilling and spillage when used properly. The Administrator has considered the advantages and disadvantages of the available control approaches in developing the proposal.

Comment: Two commenters thought that EPA should reject any suggestion that California's experience with Stage II is readily adaptable to other States or local jurisdictions, because California's Air

Quality Control Regions generally are valleys or basins surrounded by mountains. The commenters felt motorists residing in AQCR's currently covered by Stage II have little choice as to whether they purchase gasoline from a facility with Stage II equipment (I-H-108, I-H-119). These commenters (and one other) stated that the migration of customers to retail gasoline outlets without Stage II would be counterproductive to environmental objectives and would lead to a loss in tax revenues for the controlled jurisdiction (estimated as high as $47 million) (I-H-102, I-H-108, I-H-119).

Response: There would almost certainly be some migration of customers seeking to avoid using self-service dispensing facilities equipped with Stage II. However, such migration would occur only under a partial coverage scenario, and not under a scenario in which Stage II was mandated nationwide. Further, although California may have additional geographical restraints to migration, migration would occur primarily in fringe or boundary areas where unregulated stations were conveniently accessible to motorists.

Although improved Stage II equipment and increasing customer familiarity and acceptance would tend to reduce this problem, it is a factor being considered in the decision-making process.

Comment: Several commenters described present Stage II equipment as inconvenient, cumbersome, and unpopular (I-H-1, I-H-1A3, I-H-1A4, I-H-1A8, I-H-1A12, I-H-1A27, I-H-4, I-H-63, I-H-67, I-H-137). One commenter explained that the Stage II nozzles fill slowly, click off continuously, and spill gasoline (I-H-8). Several other commenters described the nozzles as heavy, bulky, and at best unwieldy, leading to bad consumer response (especially in the District of Columbia) (I-H-11, I-H-13, I-H-18, I-H-19, I-H-33, I-H-35, I-H-37, I-H-59, I-H-61, I-H-71, I-H-76). One commenter, especially noting D.C. experience, said that consumers find Stage II equipment awkward and unwieldy, and have a problem with spills on their shoes and clothing (I-H-120). Two commenters felt that the complexity, size, and weight of the Stage II nozzles could end self-service altogether (I-H-47, I-H-78). Some commenters said that the nozzles are difficult to use, unpopular with customers, and often abused (I-H-40, I-H-50, I-H-69). Two commenters noted that Stage II equipment handling problems are particularly acute for older and handicapped Americans, who might have to forego the lower cost of self-service refueling if Stage II is mandated (I-D-54, I-D-57, I-D-68, I-H-120).

Seven commenters quoted a survey completed in D.C. following implementation of Stage II that showed 68 percent of the respondents bought gasoline elsewhere to avoid cumbersome Stage II equipment, 60 percent felt that further research should have been done before implementing Stage II, and only 4 percent supported Stage II control (I-H-78, I-H-84, I-H-86, I-H-102, I-H-108, I-H-119, I-H-130). Eight commenters in the D.C. area noted an actual shift or anticipated a shift in consumer buying patterns to uncontrolled areas (I-H-4, I-H-15, I-H-18, I-H-35, I-H-37, I-H-40, I-H-76, I-H-89). One commenter stated that in both California and the District of Columbia the evidence to date indicates that consumers do not want to operate Stage II equipment and, given the choice, will purchase gasoline at facilities with conventional nozzles; i.e., at exempt facilities. The commenter cited a consumer survey at 20 service stations in Washington, D.C., indicating widespread dissatisfaction (I-H-125). One commenter felt that air quality would not be improved if a system is installed that is so difficult for the average consumer to use that he or she devises methods to sabotage or defeat the proper operation of the equipment, or if unhappy consumers find they can drive to areas without Stage II to avoid the inconvenience of buying gasoline through Stage II equipment (I-H-102).

Response: Many of the problems described by these commenters can be attributed to older, first-generation Stage II equipment at service stations. Recognizing the importance of reducing consumer complaints, manufacturers have taken action to improve system components. They state they are developing more durable, reliable, and easily used components for Stage II vapor recovery systems. Among the changes described are improvements to nozzle bellows and faceplates, vapor hoses, swivels, and nozzle latching bands and springs. In addition, nozzle manufacturers have introduced a new tear-resistant urethane-type bellows material that will be used on new nozzles and as replacements. High-retractor twin and coaxial hose and high-hang coaxial hose configurations suspend hoses off the ground. Suspended hoses are less likely to be run over and flattened. New, lighter and less cumbersome nozzles are being introduced, which should make refueling easier for more people.

The Agency believes that such recent improvements may reduce consumer attempts to sabotage, or avoid the use of, Stage II dispensing equipment. Nevertheless, Stage II is still more complicated and cumbersome than standard equipment, and some customer inconvenience can be expected where it is used.

Comment: Four commenters consider the 1982 California complaint rate (2,533 in 11 months) on Stage II to be very high, particularly when complaints were only accepted by CARB in writing (I-H-102, I-H-108, I-H-119, I-H-130). Two of these commenters cited consumer apathy and customer "avoidance" as reasons why the level of dissatisfaction in California and Washington, D.C. is potentially much higher than indicated by the numbers of complaints. The commenters felt that some motorists have learned to bypass the proper operation of the system, making use of the equipment easier, and will therefore no longer have reason to complain (I-H-108, I-H-119).

Response: The California ARB, in its March 1983 report to the State Legislature (I-F-78), noted that there are approximately one billion fuelings per year made with Stage II equipment in California. Therefore, the complaint rate amounted to about one complaint in 350,000 refueling operations. As discussed previously, improvements in equipment should reduce many of the difficulties experienced previously by users.

Comment: One commenter noted that, while consumers should be willing to pay a price in personal inconvenience for the sake of clean air, the Agency's imposition of burdens on the public (as with Stage II) is a resource that should be expended carefully. The commenters suggested that onboard would be less likely to draw down EPA's stock of public support (I-H-120).

Response: The EPA has attempted to consider all pertinent issues and aspects of the regulatory options under evaluation. Some intangible elements, such as burdening the public with part of the responsibility for maintaining air quality, are difficult to quantify so that they can be weighed against other costs. The Agency agrees that the burden to the public at-large of using Stage II equipment could be greater than that of purchasing an onboard system, and this has been considered in developing the rulemaking being proposed at this time.

3.11 REFERENCES

(Comment letters are not repeated here. See Chapter 1, Table 1-1, for a complete list of comment letters.)

I-A-22 Cost and Cost-Effective Study of Onboard and Stage II Vapor Recovery Systems. Prepared by R.A. Luken for U.S. EPA, Office of Air Quality Planning and Standards, Research Triangle Park, NC. August 1978.

I-D-38 Letter and enclosures from Crockett, P.E., American Petroleum Institute, to Garay, C.L., U.S. EPA. August 8, 1984. Information on gasoline dispensing rates.

I-E-19 Telecon. Eldridge, K., Pacific Environmental Services, with Stray, I., B.F. Goodrich. October 16, 1984. Cost of hose assembly.

I-E-20 Telecon. Levine, A., W.M. Wilson's Sons, with Eldridge, K., Pacific Environmental Services. October 18, 1984. Costs of hose configurations and dispenser.

I-E-22 Telecon. Eldridge, K., Pacific Environmental Services, with Simon, J., Petro Vending. October 26, 1984. Costs and life expectancy of components.

I-E-23 Telecon. Purcell, R., Pacific Environmental Services, with Taylor, B., Hirt Combustion Engineers. October 26, 1984. Costs of Stage II components.

I-E-25 Telecon. Purcell, R., Pacific Environmental Services, with Healy, J., Cambridge Engineering. October 29, 1984. Costs of VR system.

I-E-26 Telecon. Eldridge, K., Pacific Environmental Services, with Madden, M., Pomeco. October 29, 1984. Costs of equipment.

I-E-27 Telecon. Taggart, D., SMP Company, with Eldridge, K., Pacific Environmental Services. October 29, 1984. Costs of equipment.

I-E-37 Telecon. Eldridge, K., Pacific Environmental Services, with Van cleave, R., Ameron. January 7, 1985. Service life of fiberglass pipe.

I-E-38 Telecon. Oswald, K., A.O. Smith, Incorporated, with Eldridge, K., Pacific Environmental Services. January 9, 1985. Service life of fiberglass pipe.

I-E-47 Telecon. Norton, B., Pacific Environmental Services, Inc., with Simeroth, D., California Air Resources Board. January 30, 1985. Stage II system in-use efficiencies.

I-E-53 Telecon. LaFlam, G., Pacific Environmental Services, with Todd, D., California Air Resources Board. September 24, 1985. Resolution of spit-back problem in early Stage II systems.

I-E-54 Telecon. Simeroth, D., California Air Resources Board, with LaFlam, G., Pacific Environmental Services. September 26, 1985. Fire safety of Stage II systems.

I-F-78 Air Resources Board, State of California. A Report to the Legislature on Gasoline Vapor Recovery Systems for Vehicle Fueling at Service Stations (Stage II systems). March 1983.

I-F-98 Cost Comparison for Stage II and On-Board Control of Refueling Emissions. American Petroleum Institute. Washington, D.C. January 1984.

4.0 TRADEOFFS BETWEEN STAGE II AND ONBOARD*

4.1 GENERAL ISSUES

Comment: One commenter expressed concern over the capability of both Stage II and onboard systems to control hydrocarbon emissions from alternative fuels such as methanol and ethanol blends. They noted that the evaporative emissions of such fuels may contain oxygenated hydrocarbons in addition to the light hydrocarbons. Some of these oxygenated hydrocarbons may affect control efficiencies; for example, adsorption and desorption efficiencies of methanol on activated carbon may not be identical, which may cause saturation of the activated carbon for methanol and a resulting drop in control efficiency. The commenter concluded that while it is not clear if EPA has studied the effects of alternative fuels on Stage II and onboard controls, it is a topic that should be addressed in light of the anticipated increased use of such fuels (I-H-126).

Response: It is not anticipated that methanol or ethanol blends would affect the performance of Stage II equipment. The balance and hybrid system equipment is only a capture system and so any hydrocarbon vapors, regardless of composition, should be captured equally and piped to the storage tank. The alcohol fuel vapors also should not reduce the efficiency of the incinerators associated with vacuum assisted systems.

As discussed in Section 2.1.4(b), the Agency has conducted two separate test programs to evaluate the effects of alcohols on onboard canister working capacity. The findings were that alcohols have little or no effect in reducing the performance of the activated carbon used in onboard systems.

Comment: One commenter stated that if control of VOC emissions from motor vehicle fueling is determined to be necessary, then enhanced carbon canisters on new vehicles is the preferred approach. The commenter pointed out that the evaluation report indicates onboard to be more effective, and cited these advantages: (1) the control efficiency of onboard is higher; (2) onboard would also control excess evaporative emissions; (3) an onboard program would extend to all areas; (4) the existence of exempted facilities would not reduce the effectiveness of an onboard program; (5) the effectiveness of onboard is not dependent upon extensive enforcement actions; and (6) onboard is not susceptible to circumvention resulting from low consumer acceptance (I-H-92).

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*1984 Federal Register topic.

Another commenter agreed that onboard controls will capture not only refueling emissions, but also evaporative emissions that escape existing evaporative emission controls, and that, as the Agency pointed out, when evaporative emissions are included in the overall analysis, the emission reduction potential for onboard controls is "roughly double" that of Stage II (I-H-94).

Response: All of the issues cited by the first commenter, control efficiencies, evaporative emission controls, program coverage, exemptions, enforcement, and public acceptance, have been thoroughly considered by the Agency in evaluating control options for the gasoline marketing industry. In reanalyzing the impacts of controls, both enlarged carbon canisters and gasoline RVP limitations in combination with Stage II controls have now been considered (see Vol. I RIA).

Comment: One commenter noted that, if a consumer ruined a fill-pipe seal on a car equipped with onboard controls, only that one car would be affected. However, a disabled Stage II nozzle could refuel hundreds of cars within days (I-H-102). Another commenter felt that Stage II systems are relatively fragile compared to onboard, and estimated that the typical expected emission loss for a single car with a ruined onboard seal would be about 1,600 grams per year, contrasted with 1,600 grams per day for a defective Stage II nozzle (I-H-20).

Response: The Agency agrees that a disabled Stage II nozzle, if used to refuel a large number of vehicles before maintenance or enforcement action, could potentially allow relatively large quantities of emissions to escape. Under either control approach, proper design, installation, maintenance, and inspection are important to ensuring that the systems continue to control emissions at their optimum efficiencies.

Comment: One commenter stated that Stage II controls would save almost 100 million gallons of gasoline per year that would be lost if onboard controls are required. This advantage, the commenter pointed out, could be important beyond the current dollar value of that gasoline in a future petroleum scarcity and should not be ignored (I-H-93).

Response: The fuel savings resulting from the implementation of Stage II systems (with exemptions) was shown in Table 5-12 of the July 1984 analysis to be 8.1 billion liters of gasoline over the 35-year period of the analysis, or about 61 million gallons per year. For the no-exemption scenario, this figure increased to 86 million gallons per year. Zero fuel savings were indicated for onboard systems, because the canister weight added to the vehicle was presumed to offset any enhanced fuel economy.

These figures have been revised in the new analysis to reflect updated emission factors and a more detailed examination of onboard system designs. The Draft Volume I RIA annual fuel savings of 230 to 330 million liters of gasoline per year or about 60 to 90 million gallons per year for Stage II applied nationwide. Onboard systems are now estimated to produce a savings of 610 million liters or about 160 million gallons of gasoline per year. The Volume I RIA also shows that Stage II-nationwide plus evap controls can have an associated fuel savings as high as 650 million liters per year (170 million gallons per year). Section 2.7 discussed in detail the fuel consumption aspects of vehicles with onboard systems.

The recovery of valuable motor fuel otherwise lost is considered an important factor in the analysis of control strategies, and has been considered by the Administrator in developing the rulemaking proposal.

4.2 FACILITY EXEMPTIONS FROM STAGE II

Comment: Three commenters felt that the effectiveness of Stage II would be reduced (in contrast to the total coverage of onboard controls) because of the exemptions planned for smaller service stations, which outnumber the large facilities (I-D-54, I-H-1A14, I-H-40). One of the commenters also pointed out that governmental facilities, car rental agencies, and other commercial installations would, through exemption, continue to contribute to the emissions problem (I-H-40).

Two commenters agreed that size exemptions should be considered (I-H-42, I-H-43).

Response: Upon full implementation, Stage II would be somewhat reduced in effectiveness because of uncontrolled facilities. The magnitude of the reduction would depend upon the exemption levels selected and the intensity of enforcement programs. It is true that, depending on the exemption level, a large number of smaller facilities, including the types mentioned by the commenter, could remain uncontrolled.

Comment: A number of commenters remarked on the appropriateness of exemption size cutoffs for service stations. One commenter noted that it would be difficult to determine the gallonage (throughput) of service stations (I-H-1A14). Another commenter agreed that the true sales volume could be difficult to determine and added that seasonal fluctuations can change a dealer from exempt to regulated. In addition, they remarked that proposing a cutoff invites a battle over fairness and equity (I-H-21). Another commenter felt the Agency's suggested exemption was too large, noting that the Bay Area Air Quality Management District of California exempts tanks smaller than 260 gal from Stage I and stations with throughputs less than 180,000 gal/yr from Stage II. The experience in the Bay Area is that proposing exemptions will give rise to claims of giving an unfair competitive advantage (I-H-82). One commenter objected to the unequal treatment of independents and non-independents regarding cutoffs (I-H-24).

One commenter believed that the provisions of Section 325 apply to Section 112 standards; however, they did not think that EPA was prohibited from establishing exemption levels greater than 50,000 gallons/month. The commenter felt that a size standard of 85,000 gallons/month would be adequate to protect the same type of small marketer Congress had in mind when it amended the Clean Air Act in 1977 (I-H-102).

Response: In the 1984 analysis, EPA examined the impacts of several regulatory strategies, including Stage II at service stations. Specific options included the exemption of independent stations with gasoline throughputs less than 50,000 gallons per month, and all other stations with less than 10,000 gallons per month, and a "no-exemption" option. As stated in the 1984 evaluation report (page 1-9), these cutoffs were based on the relatively higher costs of control for small facilities, existing size cutoffs under State and local regulations, and statutory requirements for small throughput independent service stations under Section 324 of the Act. Exemption levels were again examined in the new analysis to investigate the impact on nationwide regulatory strategies. Although other levels were examined, the assumed exemption level cutoff of 10,000 gal/month for all stations and 50,000 gal/month for independents was retained. Other responses in this section and in Section 3.6 discuss the fairness of exemptions and the effects on competition. Section 10.1 discusses the legality of the 50,000 gal/month cutoff for independent gasoline marketers.

Similar exemptions are used in other emission categories to avoid imposing costly controls on low-emitting entities. The Agency believes that such an approach is fair, and comports with its objective of reducing emissions while considering impacts.

Comment: One commenter suggested that EPA exempt all stations with a throughput under 50,000 gallons per month in order to avoid competitive discrimination. The commenter pointed out that, under this approach, independent stations retain the Section 324 protection against infeasible capital expenditures, but not at the expense of their nonindependent counterparts. The same commenter stated that EPA's example exemption option would put nonindependent service stations with throughputs between 10,000 and 50,000 gallons per month at a competitive disadvantage with respect to independent stations of like size. The commenter pointed out that any prudent business entity, large or small, will analyze the economic impact of a proposed capital expenditure at any one of its operating units on a "stand-alone" basis; that is, significant capital expenditures at a service station will be evaluated in light of the revenue produced by that particular station. The commenter added that if the size of the proposed expenditure is disproportionately large relative to the revenue generated by the station, the "payback period" (the time required for the revenue generated by virtue of the expenditure to recoup the expenditure) will be unacceptably long, and the expenditure will not be made. The commenter pointed out that, assuming independent and nonindependent service station owners are equally prudent, they would decline to make such a capital expenditure at roughly the same point. In the case of a capital expenditure for mandatory Stage II controls, declining to make the expenditure would mean that the station could not legally operate and would have to close (I-H-94).

Response: Under the original 1984 exemption scenario, nonindependent facilities in the 10,000 to 50,000 gallon per month throughput size class would be at a competitive disadvantage. The reanalysis examines two additional exemption options that posit uniform size cutoffs for independent and nonindependent facilities.

Under "stand-alone" economics, the same closure decision would be made regardless of station ownership. However, Section 324 does not address this process. Rather, it is motivated by a concern about access to financing and cost impacts for independent firms. Further discussion on the statutory basis for facility exemptions is contained in Section 10.1.

Comment: One commenter granted that under a Federal program, EPA would be required by statute to grant certain exemptions, but noted that States, acting under the aegis of SIP revisions, could apply Stage II without exemptions. This commenter feels, therefore, that ultimately Stage II programs would likely cover more facilities than the current "with exemption" estimates indicate. Thus, both costs and emission reductions appear to be underestimated in the forecast (I-H-120).

Response: The commenter is correct in that States may set specific exemption cutoff levels for service stations within their jurisdictions, provided that these levels are stricter, i.e., equal to or lower, than any levels specified under Agency requirements (see Section 116 of the Clean Air Act). The reanalysis of regulatory strategies, discussed in the Draft Volume I RIA, includes the evaluation of additional exemption considerations.

4.3 IN-USE CONTROL EFFICIENCIES

Comment: Two commenters felt that EPA's assumptions concerning the in-use efficiencies of the two control approaches skewed the evaluation in favor of onboard (I-H-57, I-H-82). One of them felt that tampering with onboard controls would be considerable, causing EPA's worst-case onboard control efficiency of 92 percent to be extremely optimistic. Also, the worst-case figure for Stage II of 56 percent (minimal enforcement) is much too low, considering the commenter's experience with Stage I controls (I-H-57). These commenters felt that using correct assumptions about in-use efficiencies would show that Stage II is the superior control approach. Another commenter agreed with EPA's estimates of 92 percent for onboard and 56 to 86 percent for Stage II (I-H-94).

Response: Due to the latest design concept under consideration for the onboard system (J-tube liquid seal in fuel tank instead of nozzle/fillneck vapor seal) and the phase-out of leaded gasoline, tampering with the nozzle restrictor/fillneck should occur only rarely. The Agency now estimates an in-use efficiency of 93 percent for onboard controls. The "worst-case" estimate for Stage II in-use efficiency is now 62 percent, based on extensive observations made at controlled service stations in Washington, D.C. (I-A-61).

Comment: Several commenters thought the in-use control efficiency of onboard systems would be much higher than the efficiency of Stage II, and should be selected as the control approach that would achieve the greatest emission reductions (I-H-94, I-H-102, I-H-108, I-H-119, I-H-122, I-H-125).

Response: As discussed in the previous response and in the sections on onboard controls, Agency estimates of in-use control efficiencies have been re-evaluated. For Stage II, the range is now estimated at 62 to 86 percent, based on the latest surveys made in areas currently employing Stage II controls. For onboard, the re-analysis is based on an in-use control efficiency of 93 percent, due to negligible effects from tampering and system deterioration (see Section 2.1.2.8).

4.4 REFERENCES (Comment letters are not repeated here. See Chapter 1, Table 1-1, for a complete list of comment letters.)

I-A-61 D.C. Gasoline Station Inspections to Assure Compliance with Stage II VOC Vapor Recovery Requirements. U.S. EPA Region III. Philadelphia, PA. 9271.00/12B-N. January 1985.

5.0 EPA's 1984 CONTROL STRATEGY EVALUATION

5.1 GENERAL METHODOLOGY

Comment: One commenter remarked that EPA had attempted to find a single solution to the two problems of ozone in nonattainment areas and gasoline vapors with their associated cancer incidences. Thus, EPA compared tried-and-true Stage II systems, effective in reducing very real ozone nonattainment problems, with experimental onboard systems said to be effective in reducing speculative cancer incidences. In the process, EPA stretches its predictive capabilities to an "amazing" 35 years (I-H-21).

Another commenter felt that it is misleading to compare on common terms Stage II data from full scale public use programs with extrapolated onboard data from controlled test programs (I-H-118).

A number of other commenters thought that a period of 35 years is too long to make confident projections in the analysis of control options. One commenter felt that the cost estimates for onboard systems had been made and projected 35 years into the future without knowing the size, construction, or location of the unit. This commenter maintained that extrapolating beyond the year 2006 serves no purpose, since no one can predict whether automobiles will even be powered by gasoline engines at that time (I-H-101). Another commenter did not see the 35-year analysis as reasonable, given the uncertainties about the motor vehicle fuel of the future. The commenter felt there was no justification for a time horizon beyond 25 years (I-H-127). Finally, one commenter felt that, while the 35-year analysis period is relevant, it dramatically distorts the cost comparisons, and EPA need not make a decision in 1984 for the entire period through 2020. The commenter stated that the 35-year period inflates the apparent cost of a "Stage II only" program in which EPA mistakenly assumes that Stage II equipment must be replaced in 2002 and 2017, which more than triples the apparent capital cost of Stage II (I-H-93).

Response: The commenters in general appear to be questioning EPA's selection of 35 years (1985-2020) as the period for estimating impacts from implementing onboard and Stage II control strategies. The selection of this projection period is based on confidence that there will be a complete turnover of the vehicle fleet within 35 years and that onboard is anticipated to be fully implemented by then (most likely well before 2010). The analysis was carried out to 2020 to allow amortization of the latest cycle of Stage II equipment. Thus, the two control approaches can be compared after they both are at their full coverage. Two analysis approaches were evaluated in the comparison of the regulatory strategies: (1) a net present value (NPV) analysis that evaluated all future costs and analyzed the future cost stream in 1987 dollars, and (2) an analysis for the year 2010 that compared the costs of all strategies after full implementation was reached. These analyses do not distort the cost comparisons but instead provide a reasonable solution to evaluating regulatory strategies that have significantly different implementation rates.

The EPA agrees with one of the commenters that there are some uncertainties about motor vehicle fuel in the future and the effect this might have on gasoline marketing controls. In spite of these uncertainties, however, EPA must use the best data available in estimating impacts of these controls.

The EPA has looked not only at single strategies to control the complex emissions associated with gasoline marketing, but also at combinations of strategies. For example, a regulatory strategy was evaluated that combined onboard (which leads to the greatest long-term VOC and incidence reduction) with Stage II in nonattainment areas (which could achieve faster control of ozone in the areas where it is most needed.)

Section 2.1 contains a response to the concern that onboard technology has been evaluated only during controlled test programs. Section 3.4 discusses the changes made in the analysis to better estimate the replacement cycle and replacement costs associated with Stage II.

Comment: Two commenters felt that EPA's analysis should not have included the benefits of reduced hot soak evaporative emissions in the determination of the cost effectiveness of onboard controls (I-D-58, I-H-95). One of them said the Agency should analyze other alternatives for its control (such as enlarging the existing carbon canister or limiting the RVP of gasoline in summer months), and should evaluate the cost effectiveness of measures that address refueling and hot soak evaporative emissions as separate issues constituting the complete problem. Three potential measures would be: (1) onboard controls, (2) Stage II vapor recovery combined with enlarged carbon canisters required on new cars, and (3) Stage II vapor recovery combined with a limitation on the RVP of gasoline sold in the summer months. If additional control alternatives for evaporative emissions are not evaluated along with onboard controls, evaporative emission reduction credits should not be included in the evaluation of regulatory strategies (I-H-95).

Another commenter stated that the inclusion of excess evaporative controls distorts the onboard analysis. The commenter feels this should be excluded because: 1) evaporative emissions do not have the same health implications as refueling vapors because they are not emitted in the breathing zone, 2) onboard controls will not assure the elimination of excess emissions that exist due to fuel volatility, 3) the fuel volatility difference between certification fuel and commercial gasoline must be eliminated or reduced, and 4) the analysis did not analyze other approaches to the control of fuel volatility (I-H-114).

Another commenter further contended that the consideration of excess evaporative emissions and their control should not be a part of the analysis, noting that EPA had recently announced its intent to eliminate the current volatility difference between commercial and certification test fuels (I-H-127).

Response: The EPA's revised analysis considered the three alternative measures posed by the first commenters. The first alternative, onboard controls without controlling excess evaporative emissions, is not reasonable because the control of excess evaporative emissions is an integral part of the current onboard system concept. Therefore, it is not technologically feasible to implement the onboard program without controlling excess evaporative emissions. However, EPA did evaluate the impacts of an onboard strategy incremental to evaporative controls (thus assessing onboard on the basis of refueling only).

The EPA has evaluated the second and third alternatives, enlarged carbon canister controls in conjunction with Stage II vapor recovery systems and the combination of Stage II systems with RVP controls. The EPA's Office of Mobile Sources (OMS) is studying the elimination of the current RVP difference between certification fuel and commercial gasolines, and placing limitations on gasoline RVP during the summer months, which includes options to increase and change the evaporative canister system (I-A-66). These alternatives have been considered in the revised analysis.

In response to the second commenter's first point, that excess evaporative emissions should not be included in the onboard analysis because of differences in health implications, EPA in its reanalysis examined the effects of using an onboard system to control refueling vapors in conjunction with excess evaporative vapors. (Both of these sources of emissions would be controlled by an onboard system.) Further discussion on approaches to control of excess evaporative emissions is contained in Sections 2.1.7 and 2.6.4.

Comment: One commenter remarked that it was difficult to verify EPA's estimated bulk terminal and bulk plant emission reductions and corresponding recovery credits. The commenter suggested that EPA should clarify the assumptions used and provide sample calculations (at the bottom of the tables in a way similar to Table 7-10 of the 1984 report). The commenter cited some specific examples of recovery credit calculations requiring clarification: (1) The gasoline throughput rate and units for Q are not provided in Table 7-5 to verify calculations based on bulk terminal internal floating-roof losses of (7.3285×10^{-3} Q) + 2.4 Mg/yr. They noted that on pages 2-12 and B-22, the floating-roof tank withdrawal losses are given as 0.46×10^{-7} Q where Q is in barrels/yr. (2) The bulk plant emission reduction changes with size of plant and type of control as expected; however, the recovery credit does not change with type of control. They considered it illogical that with an exemption, the smallest plant would have a higher recovery credit. They noted that the recovery credits in Tables 7-6 and 7-7 could not be verified (I-H-126).

Response: The units for Q in the internal floating-roof emission factor equation are in barrels of product per year. A weighted Q was used to calculate the recovery credits. This weighted Q was based on the bulk terminal model plant throughputs, number of tanks assumed for each model plant, and the distribution of each model plant. The weighted annual throughput used for the internal floating-roof recovery credit calculations was approximately 2,700,000 barrels per year.

An error was discovered in the recovery credit calculations for bulk plants under the no-exemption option. The original 1984 analysis included only the emission reductions attributed to the storage tank draining losses and not the emission reductions associated with the tank truck loading operations. This error has been corrected in the revised analysis.

Comment: One commenter felt that Stage II capital costs should be calculated using actual data from California and that onboard should be credited with MOBILE3 credits for evaporative emissions capture. If these changes in the analysis are made, onboard then becomes three times more cost effective than Stage II (I-H-120).

Response: In EPA's reanalysis, Stage II costs were revised based on California-certified systems. These revised costs are presented in Appendix B of the Volume I RIA. In the revised analysis, EPA displays results for onboard both with and without excess credit for evaporative emissions capture.

Comment: One commenter claimed that the three types of Stage II systems described in paragraph 3.7.1 of the evaluation report do not include the system manufactured by his company. The commenter noted differences between his system and a system described in the report, and stated that these differences form the basis for his system's superior performance (I-H-129).

Response: The EPA's July 1984 analysis discussed three types of Stage II systems being used currently in California and the District of Columbia: the vapor balance, the hybrid, and the vacuum assist system. The commenter's system is apparently a vacuum assist type system with some differences in detail from the general description EPA provided. It was not feasible to describe fully in the report the various specific systems currently available. Moreover, it is highly unlikely that the Agency would base its regulation on a particular system of a given technology for control of refueling.

Comment: One commenter felt that EPA did not make a balanced use of information from the oil and auto industries in its analysis, since the list of references in the EPA report includes many references from the oil industry (I-H-118).

Another commenter felt that EPA's almost sole reliance on a single API report on the effectiveness of onboard controls is questionable given the oil industry's economic interest in promoting onboard controls. The commenter recommended that EPA use an independent means of verifying any data from any industry with an economic interest associated with the result (I-H-90).

Response: Throughout the development and analysis of regulatory strategies for controlling emissions from gasoline marketing, EPA has requested, received, and considered input from all interested parties. On June 27, 1978, the Agency solicited (43 FR 27892) information on the costs and effectiveness of possible controls on motor vehicle refueling (I-G-5). Respondents to the Federal Register notice included API, General Motors, Ford, and AMC. With regard to Stage II, the recent practical experience and recommendations of authorities in California and the District of Columbia have been closely studied. Moreover, in 1984 EPA solicited comments on its draft evaluation of gasoline marketing strategies. As discussed in Appendix C of the EPA July 1984 analysis report, the API, GM, and Ford information contained data from tests with onboard control hardware. All of these data have been reviewed and analyzed by EPA.

Since the publication of the July 1984 analysis, EPA's Office of Mobile Sources (OMS) has developed and tested a liquid seal configuration for onboard control systems that addresses many of the concerns commenters had with regard to the mechanical seal (nozzle/fillpipe interface) (Section 2.1.2 describes this design concept in more detail). The 1978 studies of API and its contractors, the technical input and comments of the auto makers, as well as comments solicited on the material in the July 1984 analysis (I-G-15), and subsequent experimental work and analysis by OMS have been carefully considered by EPA in arriving at the regulatory proposal.

Comment: One commenter felt that the calculations using equipment useful lives are appropriate only for equipment placed in service prior to 1980. Recovery of capital costs for tangible depreciable property placed in service after 1980 is accomplished through a method called Accelerated Cost Recovery System (ACRS). Under this method, the cost of an asset is recovered over a predetermined period that is generally shorter than its useful or income-producing life, while salvage value is disregarded. Under ACRS, an automobile or light-duty truck is considered to have a life of 3 years, while bulk terminal, bulk plant, and petroleum storage equipment is considered to have a life of 5 years. This commenter suggested that since most businesses have to use the ACRS method for capital cost recovery, EPA should use a similar method that more reasonably reflects the tax consequences of control equipment. The commenter added that the true cost of the control systems depends on the type of financing, debt/equity ratio, depreciation schedule, tax effects, and other factors (I-H-126).

Response: The EPA's cost analysis is a before-income tax analysis and, consequently, it does not address the tax implications of control equipment. The before-tax approach is chosen for several reasons. First, the main purpose of the cost analysis is to estimate the social or real resource costs of regulatory strategies. From an aggregate or societal viewpoint, a tax on net earnings is best viewed as a transfer of resources from the private to the public sector, rather than as a real resource cost. Of course, individual firms would consider the tax consequences of control equipment, and the market would reflect this consideration. However, computation of likely tax impacts is confounded by the wide variety of firms, firm conditions, and firm accounting practices in the industry, and by possible competitive pressures created by the regulatory strategies. Furthermore, in other analyses it has been observed that before- and after-tax cost impacts do not differ markedly. Depending on tax rates, credits, depreciation, other taxable income, etc., the after-tax costs can be higher or lower than the before-tax costs, so no prior belief about the direction of the difference between the two methodologies can be held. In this case, EPA used before-tax calculations of costs for the preliminary economic analysis (excepting the local tax discussed above). Questions concerning the appropriate depreciation schedule in this context are moot.

In order to better respond to the comment, however, EPA has computed before-tax and after-tax costs per unit of throughput by model plant for Stage II control. For all computations, EPA assumed that the cost of capital was 10 percent. For the after-tax case, a 10 percent investment tax credit was claimed, the 95 percent basis for depreciation of environmental control equipment was chosen, and accelerated cost recovery was applied to capital equipment. The results displayed in Table 5-1 show that the per-liter average total cost of control for each model plant is slightly less before taxes than after taxes. Differentials between before-tax and after-tax estimates range from less than 0.03¢/liter to 0.076¢/liter. The percentage differences between before-tax and after-tax estimates are within the error bounds of the cost calculations and the limits of accuracy of the impacts methodology. Larger percentage differences are observed only when the before-tax cost of control is close to zero.

Whether income tax payments represent real resource costs or whether they represent, all or in part, a transfer of resources from the private to the public sector, depends on what assumptions the analyst is willing to make about the value of the services provided in exchange for these tax payments and the relative tax burden associated with these investments relative to the average investment made in the economy. In this analysis, EPA chose to treat taxes on net income as a transfer, and thus not a real resource cost from an economic perspective.

Comment: One commenter noted that the net present value (NPV) rate of time preference approach used in the evaluation normally applies to income or other positive values. For health risks associated with emissions, the time preference would be negative; given a choice between emissions now or later, later will usually be chosen. The commenter felt that this creates differences from the traditional incremental steps involved in a yearly discount rate, and raises questions about the methodology (I-H-24).

Response: While the time preference with regard to emissions (and associated health risk) is negative, the time preference with respect to reductions in emissions is positive. Thus, the application of NPV analysis to emission reductions is consistent with the traditional time preference approach. Moreover, the NPV's included in the analysis are calculated in the traditional manner: emission reductions are determined incrementally, discounted, and summed to arrive at the present value of emission reductions.

Table 5-1. STAGE II AVERAGE TOTAL COST OF CONTROL BY MODEL PLANT (1984 ¢/liter)

Tax basis[a]	MP1	MP2	MP3	MP4	MP5
Before tax	1.756	0.526	0.552	0.367	0.105
After tax	1.956	0.602	0.627	0.421	0.133

[a] All calculations assume a 10 percent cost of capital. After-tax estimates also assume a Federal tax rate of 46 percent, a State tax rate of 6 percent, a 10 percent investment tax credit, the 95 percent basis for depreciation of fixed capital after the tax credit, and accelerated capital recovery based on 5 years on an accelerated depreciation schedule.

Comment: Two commenters believed EPA's cost analysis was faulty and a significant departure from previous Agency analyses in that it used a discount rate to discount emissions, rather than discounting the monetized benefits of emissions reduction (I-H-102, I-H-120). One commenter (I-H-102) argued that, just as society has a preference about the timing of emission reductions, it must also have preferences concerning various levels of emission reductions. In order to determine the best strategy, the analysis should calculate the costs and benefits of reducing VOC each year under the various strategies, express them in monetary terms, and then discount them. However, the evaluation document did not furnish the necessary information to do this. Since this information is not available, one can instead discount emissions as EPA has done, and select different discount rates based on the VOC reduction potential of the various strategies. This would mean that onboard would be assigned a higher rate of discount than would any of the various Stage II options. Using EPA's sensitivity analysis, it would be appropriate to assign onboard the rate of 10 percent and Stage II the rate of 5 percent. Under the use of this discounting method, Stage II costs double, while onboard costs remain the same (I-H-102).

The other commenter (I-H-120) stated that a more traditional approach would assign a monetary value and take the net present value of the monetized stream of benefits. Calculating the number of years required to achieve a certain level of cumulative VOC reductions is another alternative. This commenter felt that further consideration should be given to the most appropriate method of comparing streams of costs with streams of benefits.

Response: It is not necessary to discount the monetary equivalent of emission reductions if all units of reduction are assigned the same value, as they are in this analysis. The monetary value is needed as a common basis for evaluation only if, for example, the value of the last unit of emissions reduction is different from the first. Placing the same value on each unit of reduced emissions, regardless of the current emission level, is consistent with a linear dose-response function constructed independently of baseline emissions. Since the risk analysis is based on the linear dose-response function, the discounting of emissions in this manner is appropriate.

Discounting is used to remove the time element from investments with diverse time streams so that they can be compared. The discounting procedure captures the effect of time without the use of different discount rates for various projects. Adopting different discount rates to reflect diverse time streams would defeat the purpose of discounting, which is intended to account for variations in timing by applying the same calculation methodology to all alternatives.

Comment: One commenter suggested that a more accurate cost comparison can be achieved using the ratio of vehicles that would be equipped with onboard controls to each service station that would be required to have Stage II. The commenter felt that costs in both cases should include initial installation, maintenance and repairs, total enforcement costs, and level of effectiveness (I-H-90).

Response: Using ratios of vehicles and service stations complicates the analysis and introduces uncertainty, due to varying distributions of vehicles and service stations, ratios of controlled to uncontrolled sources, exempted categories of sources, and other factors. The Agency believes that the best nationwide total cost estimates can be made by first determining the most accurate component and system costs, and then multiplying these values by the total number of emitting sources likely to have the controls installed. All of the cost categories mentioned by the commenter were considered in the cost analysis.

Comment: One commenter differed with the assumption that onboard is an all-or-nothing choice, i.e., that it would be impossible to have differently equipped cars going to different geographic areas. They felt this truncated the analysis artificially since respected academicians have suggested the appropriateness of a "two-car" strategy and California already receives different cars from the rest of the country. The commenter suggested it might be possible to impose special requirements on cars shipped for sale in ozone nonattainment areas (I-H-120).

Response: In the Agency's reanalysis, both a 49-State and a 50-State analysis was reviewed. California was excluded from coverage by vehicles equipped with onboard controls under the 49-State scenario. Stage II is prevalent throughout the more populated areas of the State, and vehicles destined for California have different emission requirements, so the presumption of different refueling controls is logical and its implementation would be feasible. On the other hand, the advisability of extending this type of strategy to other areas is highly doubtful. The EPA considers it nearly impossible to target vehicles sufficiently over such a large number of individual areas, and the travel of most vehicles outside of their relatively limited "designated" areas would cause the effectiveness of such an approach to be lost quickly.

Comment: One commenter felt that the approximate $100 million cost per cancer incidence reduction calculated by EPA (Table 1-12 of the 1984 EPA analysis report) for the nationwide regulatory strategies was applicable only to ozone attainment areas. In EPA's analysis, various values for the concurrent VOC reductions for ozone control are subtracted until, at $2,000/Mg for VOC control, the benzene cancer incidence reduction cost is zero. The commenter thought this methodology was flawed because VOC reduction has significant value only in ozone nonattainment areas (I-H-127).

Response: The EPA agrees that VOC reduction can be considered to have its greatest "value" in ozone nonattainment areas. Nonetheless, VOC reduction in other areas also has considerable value. It is difficult to place relative quantitative values on environmental improvements because many diverse, often conflicting value systems and priorities can be applied in making such evaluations. The EPA has performed a new analysis (presented in Section 3.4 of the Draft Volume I RIA) that assumes various benefit values for VOC reductions. In the revised analysis, most of the regulatory strategies show a net cost benefit at a value of $1,000 per megagram of VOC (nationwide average).

5.2 EMISSION ESTIMATES

Comment: Several commenters questioned the validity of the results from EPA's original test program to estimate in-use evaporative emissions. Two of the commenters felt that the figure of 0.13 gram per mile was probably incorrect, and may be twice as high (I-H-109, I-H-114). Another said that the reliability of the preliminary emissions data was questionable, due primarily to the nonstandard test procedures used (I-H-125). Finally, one commenter thought that the Agency should not use its original test results for any regulatory action until repeat tests have been completed, and gave the following reasons: (1) contradictions between the results from tests conducted by EPA and the results of California's in-use surveillance program, and (2) the serious flaws pointed out to EPA by API and MVMA in EPA's tests on the failure rate of recent model passenger cars with respect to evaporative emission standards (I-H-99).

Response: As was stated in Appendix C to the 1984 Gasoline Marketing Study, EPA's preliminary assessment that a problem exists with excess evaporative emissions in-use was based on a vehicle evaluation and testing program which was in progress at that time. The problem of excess evaporative emissions and increased in-use fuel RVP has subsequently been characterized much more thoroughly and confirmed, and has become the subject of a separate EPA study. Much more information on those issues can be found in that study (I-A-66). Nevertheless, the question of the validity of EPA's test results is not an issue for analyses regarding the control of refueling emissions, since refueling emissions control is being evaluated incremental to any measure to address problems with excess evaporative emissions.

5.3 ENERGY IMPACT ANALYSIS

Comment: One commenter felt EPA's discussion of energy impacts was too brief and did not allow verification of the calculations, since assumptions and methodologies were not described. This commenter believed that the following information is required in order for the analysis to be evaluated: (1) assumed yearly throughput and uncontrolled emissions for each of the industry segments, and (2) assumed energy requirements for operation of control equipment and the effect on energy savings of the various control strategies (I-H-126).

Response: A simplified energy impacts analysis was included in the 1984 strategies analysis to determine the amount of vapors recovered as product under each of the regulatory strategies. It is true that a more detailed energy analysis could be performed; however, most of the control systems evaluated, with the exception of vapor processors at bulk terminals and incinerators in some (about 5 percent) of the Stage II systems, are passive or displacement type systems and use or consume no energy. Therefore, in most cases, the recovery credits are equivalent to the energy savings. A revised energy analysis, using the same methodology as used previously, is presented in Section 2.4.2 of the Draft RIA Volume I.

5.4 GASOLINE CONSUMPTION PROJECTIONS*

Comment: One commenter stated that EPA's assumption of declining gasoline consumption was inconsistent with its own recent projections contained in the lead phasedown proposal of August 2, 1984 (I-H-127).

Another commenter summarized gasoline consumption projections from various sources, noting that they varied from 80 to 97 billion gallons in 1990 and that the DOE forecasts for 1990 have been increasing over the past few years. Apparent trends in consumer preferences toward larger, less efficient cars have resulted in higher demand efficiencies. Therefore, given the importance of gasoline consumption projections to the overall assessment, the commenter suggested that the analysis should reflect an understanding of the variability and uncertainty of recent projections, even through the midterm (I-H-126).

Response: Projections of future gasoline consumption are subject to as much speculation and uncertainty as forecasts of future gasoline prices and, in fact, these two parameters are closely related. The difficulty in making these estimations lies in their dependence on influences that are traditionally hard to predict, such as the preferences and tastes of consumers, the world economic situation, and so forth. Estimates from all available sources are regularly updated to reflect these and many other variables. The projections made in "Regulation of Fuels and Fuel Additives; Lead Phase Down," 49 FR 31032 (August 2, 1984), were not yet completed when the final drafts of the strategies evaluation report were being prepared. Furthermore, the projection methods used in the two forecasts relied on different types of information, i.e., world supply estimates versus consumer usage habits, to calculate the results. Even though the results are somewhat different, both sets of figures are considered by the Agency to be valid for the purposes for which they were intended.

In summary, EPA is aware of the uncertainty inherent in all projections of this type. To the extent that the EPA analysis underestimates fuel consumption, then the analysis also underestimates risk, emissions capture, incidence reduction, and recovery credits, and overestimates the several cost parameters. For this reanalysis, updated projections of future gasoline consumption have been prepared.

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*1984 Federal Register topic.

5.5 SIZES AND DISTRIBUTION OF FACILITIES*

Comment: Two commenters felt that EPA has ignored trends toward a smaller number of service station facilities and larger throughputs for the remaining facilities, and that correcting for this would reduce Stage II cost estimates by 30 percent and increase emission reductions by 30 percent (I-H-114, I-H-127).

Response: A new set of facility projections has been developed that incorporates a change in size distribution based on a shift toward larger service stations (see Appendix D of the Draft Volume I RIA). The throughputs of all model plant sizes were assumed to decrease uniformly in proportion to the decrease in nationwide consumption. A percentage of the throughput decrease of smaller model plant stations was projected for closure in each year and a number of new, larger stations were added. The number of new stations added was estimated such that the throughput of the larger new stations equalled the throughput of the small stations that closed. In this manner the number of stations, when multiplied by their respective model plant throughputs, would approximate the total gasoline consumption projections.

The facility projection methodology developed by EPA does not produce major effects on the emission reduction calculations, since the emission reductions are based on total gasoline consumption and not on the number of facilities. (Minor effects are noticed because the shift from small to large facilities affects the number of facilities and the amount of throughput exempted each year due to size cutoffs). The facility cutoffs had a major effect on reducing the cost estimates for the Stage II strategies. Fewer numbers of stations results in lower costs. Of course, new data on unit costs produced upward pressure on overall Stage II costs. The net effect is shown in the Draft Volume I RIA.

Comment: The same commenters stated that an average throughput of 2,000 gallons/month better represents exempt stations less than 10,000 gallons/month (i.e., represented by Model Plant 1) than the EPA assumed average value of 5,000 gallons/month. The commenters suggested that using the alternate value reduces the throughput exempted from controls by 7 percent (I-H-114, I-H-127).

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*1984 Federal Register topic.

Response: The representative throughput selected for Model Plant 1 was reconsidered. The 5,000 gal/mo average throughput for all Model Plant 1 facilities was changed to an average throughput of 2,000 gal/mo for "private" facilities and an average of 6,000 gal/mo for "public" facilities.

Comment: One commenter thought that EPA's assumed total number of service stations appeared high, pointing out that the 103rd edition of the Statistical Abstract of the United States (December 1982) reports this figure for 1981: 153,500 retail gasoline stations, deriving at least 50 percent of their gross revenues from the sale of gasoline. No estimates for 1982 are available, but they are expected to be even lower. In addition, the commenter stated that there were 17,300 franchised and an unknown number of nonfranchised convenience stores in the U.S. in 1982. Assuming all franchised convenience stores dispense gasoline, the total number of "public" service stations would be 170,800, nearly 20 percent lower than the 210,875 assumed by EPA. The commenter went on to say that while EPA's estimates for some of the "private" outlets (e.g., trucking and local service, taxis, and school buses) appear reasonable, the government and miscellaneous categories seem high since they correspond to averages of 1,709 and 1,900 facilities, respectively, per State (I-H-126).

A second commenter pointed out that, while EPA had estimated that the number of stations would not increase appreciably, the number has steadily decreased in recent years (I-H-127).

Response: Several new publications were researched for current data on the number of service stations nationwide. As indicated by this commenter, the 103rd edition of the Statistical Abstract reports 153,500 retail gasoline stations for 1981. Also, this report states that there were 17,300 franchised convenience stores, which results in 170,800 (153,500 + 17,300) total "public" service stations.

The December 1984 issue of National Petroleum News (NPN) reports the preliminary and incomplete findings of the U.S. Census Bureau's 1982 count of service stations as 116,154 (for service stations that derive at least 50 percent of their gross revenues from sale of gasoline) (I-F-126, I-F-127). The 1984 NPN Factbook estimated the total number of all service stations in 1982 to be 144,690 (I-F-124, I-F-125). As reported in the January 1985 issue of NPN, the Department of Commerce, Bureau of Industrial Economics, estimated the number of service stations that derived at least 50 percent of their gross revenues from the sale of gasoline as 144,690 in 1982, 136,570 in 1983, and 132,000 in 1984. In addition, their estimates of franchised convenience stores were 14,683 in 1983 and 15,331 in 1984 (I-F-128). The Lundberg estimate for mid-1984 of 190,000 "public" retail outlets, including convenience stores, is also discussed in the January 1985 issue of NPN.

In light of these recent estimates and the continuing decline in the number of service stations, the Agency's original estimate of 210,875 "public" service stations was revised to reflect the Lundberg mid-1984 estimate of 190,000 public stations. The estimated number of "private" outlets was not changed, since no new information was available for this category.

Comment: One commenter felt that EPA's assumptions concerning the distribution of bulk terminals led to a serious underestimation of the costs to implement Stage I vapor controls. The commenter (an oil company) stated that 67 percent of its terminals subject to potential Stage I controls use top loading, and would require conversion to bottom loading in order to be compatible with the Stage I system (EPA had assumed only 10 percent would need this conversion). Also, the commenter indicated that all of its terminals subject to controls use submerged loading, whereas EPA had assumed that 10 percent use splash loading. This assumption inflates the apparent benefits of Stage I controls by leading to a larger gasoline recovery credit due to the controls. The commenter recommended that EPA re-examine its bulk terminal model plants and reassess its calculation of control costs at terminals (I-H-125).

Response: The assumptions relating to the distribution of bulk terminals used in the Stage I cost analysis were based on information obtained in developing the 1980 proposal of the recently promulgated (August 1983) New Source Performance Standards for bulk gasoline terminals (I-A-34). In re-evaluating these assumptions, the Agency determined that approximately 60 percent of the facilities in attainment areas (currently uncontrolled), are practicing top loading of tank trucks. This assumption is based on inputs from throughout the industry, including many smaller oil companies. Whereas it was assumed in the original analysis that 10 percent of all uncontrolled facilities use splash loading, it is now estimated that 10 percent of the top loading facilities (6 percent of all uncontrolled facilities) practice splash loading. These new assumptions have reduced recovery credits slightly and increased estimates of the net cost for incorporating vapor recovery controls at bulk terminals.

5.6 REFERENCES (Comment letters are not repeated here. See Chapter 1, Table 1-1, for a complete list of comment letters).

I-A-34 Bulk Gasoline Terminals - Background Information for Proposed Standards. U.S. EPA. Research Triangle Park, NC. EPA-450/3-80-038a. December 1980.

I-A-66 Study of Volatility and Hydrocarbon Emissions from Motor Vehicles. U.S. EPA, Office of Mobile Sources. EPA-AA-SDSB-85-5. November 1985.

I-F-124 Service Station Shakeout Continues. 1984 National Petroleum News (NPN) Factbook Annual Issue, 76(6a):103.

I-F-125 Service Station Population by States - 1984 vs. 1977. 1984 NPN Factbook Annual Issue, 76(6a):104.

I-F-126 Latest Station Count 21.4% Below 1977;Fuel Oil Dealer Population Falls 17.5%. National Petroleum News, 76(12):34. December 1984.

I-F-127 Census Bureau Data - Service Stations/1982-1977. National Petroleum News, 76(12):35. December 1984.

I-F-128 Slide in Station Count Ebbing; Survivors Start to Get Fitter. National Petroleum News, 77(1):28-29. January 1985.

I-G-5 On-Board Hydrocarbon Technology. Study of the Feasibility and Desirability. U.S. EPA. 43 FR 27892. June 27, 1978.

I-G-15 Regulatory Strategies for the Gasoline Marketing Industry. Notice of availability of a regulatory strategies analysis document for public comment. U.S. EPA. 49 FR 31706. August 8, 1984.

6.0 REASONABLENESS OF CONTROL COSTS VERSUS HEALTH RISK REDUCTION

6.1 NEED FOR STANDARDS

Comment: One commenter felt that refueling emissions represent only a small part of VOC emissions and their recovery by either Stage II or onboard controls will make only a minor contribution to ozone attainment goals, and at considerable cost per unit of VOC controlled (I-H-102).

Several commenters pointed out that previous measures (i.e., Stage I, consumption decrease, Stage II in California and Washington, D.C.) had minimal or no measured effect on ambient ozone levels (I-H-1, I-H-1A11, I-H-1A27). One commenter stated that Stage II controls have "not been proven to improve the quality of our air" (I-H-1A11), while another thought that implementation of Stage II recovery would not result in a significant improvement in air quality (I-H-1A20).

Response: Both Stage II and onboard systems have the capability of reducing the release of hydrocarbon vapors to the atmosphere. In-use efficiencies for Stage II and onboard have been determined to be 62 to 86 percent and 93 percent, respectively. The volatile organic compounds (VOC's) in these vapors are known to participate in atmospheric chemical reactions that produce ozone. While refueling emissions are not a major proportion of the VOC emissions in all areas, they constitute a significant fraction of the uncontrolled emissions in most urban ozone nonattainment areas.

California's Air Resources Board has noted that, in 1981, Stage II systems in California reduced 48,000 tons of hydrocarbon emissions (130 tons per day), and prevented the waste of 15 million gallons of gasoline (based on 10 billion gallons dispensed) (I-F-78). The EPA believes that proportional reductions associated with refueling control will serve to improve the air quality in the many areas with current ozone problems.

Comment: One commenter stated that society has limited resources to devote to its problems. This commenter felt that, when billions of dollars are to be devoted to a problem that even EPA admits will show no measurable improvement for the effort, there are dozens of other environmental health problems that would respond more favorably (I-H-101).

Two other commenters felt that the available data on the health effects of gasoline emissions and/or ozone do not justify the expenditures required under the control strategies (I-H-24, I-H-116). Another commenter felt that unless the facts pointed to significant human health effects, then the cost of $15 per car on 10 million cars (per year) could be better spent in other health areas (I-H-28).

One commenter remarked that gasoline fumes are an important contributor to ozone problems and must be curbed, especially in areas where Stage I and Stage II controls are not yet in place. This commenter expressed concurrence with the view that gasoline vapors are carcinogenic, and added that recent evidence now links benzene with additional forms of human cancer besides leukemia. The commenter felt there could be no valid basis for postponing regulatory action in light of this evidence as well as the potential ozone reductions. Finally, the commenter cited the following measures as being necessary parts of any regulation: installation of Stage I controls by 1987 on all sources not yet having them, installation of onboard on new vehicles beginning model year 1987, and installation of Stage II in all ozone nonattainment areas by 1987 (I-H-115).

Another commenter was supportive of controls on the gasoline marketing industry, since these controls (Stage I and Stage II) have proven to be very cost-effective and have saved millions of gallons of fuel annually in his State (I-H-118).

One commenter felt that a nationwide program is warranted if either the cancer risk is shown to be significant or if such a program is shown to be a cost-effective way to help areas attain the ozone standard (I-H-98).

Response: The comments illustrate the variety of opinion surrounding this controversial issue. EPA believes that the control costs are warranted. The basis for this decision is thoroughly discussed in the preamble to the proposed rulemaking.

Comment: One commenter felt that implementation of both the onboard and Stage II nationwide control approaches is not warranted, and EPA should act to discourage Stage II at the State level (I-H-113).

Two other commenters expressed strong opposition to the option of onboard nationwide plus Stage II in ozone nonattainment areas. The backlash from having two different systems with the same purpose being implemented at the same time would be considerable (I-D-70, I-H-124).

Response: Although the simultaneous implementation of both onboard and Stage II would involve certain inherent difficulties, the Agency does not consider them insurmountable. These difficulties were considered in developing the regulatory proposal. Although EPA is not requiring the implementation of Stage II as an interim measure in nonattainment areas where it is not now in place or in the process of being installed, it may be effective in particular situations. The EPA will support State implementation where the State determines that the strategy is appropriate and desirable.

Comment: Two commenters saw no advantage in adding new service station controls in areas where there is no danger of exceeding the national ambient ozone standard (I-H-42, I-H-43). One commenter supported the need for control in certain communities, but did not favor Stage II on a statewide or nationwide basis (I-H-1A20).

Another commenter stated that EPA should delay the decision on this "expensive and controversial" control measure until a conclusion is reached on the health effects issue. The commenter stated that he understood the need for controls in nonattainment areas, but did not see why nationwide control was needed (I-H-104).

Response: The rationale for the proposal of onboard controls is thoroughly discussed in the preamble to the proposed rulemaking. In part, onboard was selected for proposal because of greater long-term VOC (and therefore ozone) reduction benefits.

Comment: Three commenters claimed that the levels of benzene in gasoline vapors are below those posing a human health risk, and thus standards are not needed. They pointed out that EPA has decided not to regulate certain other sources of benzene because the Agency had determined the maximum lifetime risks posed by those sources (about 1×10^{-4}) to be insignificant. Since EPA's analysis predicts a lifetime risk from high exposure to be 1.1×10^{-5} at uncontrolled self-service stations and 1.2×10^{-4} at the boundary of a complex of uncontrolled bulk terminals, a similar finding of no Federal action necessary should be made in this case (I-H-91, I-H-94, I-H-100). Another commenter stated that the estimate of lifetime risk from benzene of 2.4×10^{-6} "baseline" for service stations is well below the level defined by EPA's own Carcinogen Assessment Group as "negligible" (I-D-58, I-H-117).

Response: The Agency is proposing to regulate vehicle refueling emissions for a number of reasons, including the benefits of reducing VOC emissions in nonattainment (and attainment) areas, and the benefits from reducing exposure to known or probable carcinogens in gasoline vapors (including benzene, a known human carcinogen, and the mixture of gasoline vapors, which is considered a probable human carcinogen). The decision to proceed with a proposal is not based primarily on the reduction of hazardous emissions but rather an overall assessment of total benefits.

Comment: Several commenters thought that the human health risk posed by EDB, EDC, and benzene in gasoline vapors is unproven or too small to warrant regulation. Others stated that refueling vapors in general do not present a significant risk that would justify controls. These commenters generally felt that the existing scientific data, as revealed in EPA's analysis, as well as the literature on epidemiological studies, are insufficient to justify any program to control these emissions (I-D-55, I-D-63, I-H-11, I-H-28, I-H-91, I-H-94, I-H-99, I-H-100, I-H-102, I-H-108, I-H-109, I-H-113, I-H-114, I-H-117, I-H-119, I-H-120, I-H-127). Two of them claimed that EPA's own estimates demonstrate the risks to be too small to warrant Federal regulation (I-H-102, I-H-113). One commenter said that epidemiological studies of workers indicate no major health problems (I-H-11). Another expressed the view that, if EPA determines refueling controls to be a cost-effective way to achieve ozone goals, the rationale for this conclusion should be distributed in a separate document for public comment (I-H-99). Four commenters felt that additional data on health risk should be collected, and that the Health Effects Institute should examine these data for soundness (I-H-101, I-H-114, I-H-116, I-H-127). Another thought that the nationwide control strategies should be set aside until a human health hazard has been determined, subjected to peer review, and accepted by EPA's Science Advisory Board (I-H-107). A final commenter suggested that EPA expedite its cancer research in the area of gasoline vapor and resolve the risk analysis, which is now only preliminary (I-H-98).

A number of commenters also concurred that controls to address EDB and EDC are unwarranted in light of the small present exposure levels and the certainty that even these small exposures will rapidly decrease as leaded gasoline is phased out of the market (I-H-83, I-H-91, I-H-94, I-H-99, I-H-101). One of these commenters stated that since EDB and EDC are not listed as hazardous air pollutants under Section 112, the basis for imposing nationwide vapor recovery to reduce exposure to these compounds is even weaker than for benzene. The commenter stated that assuming the Agency's new lead phasedown strategy is successful, annual sales of leaded gasoline should fall more rapidly than EPA's original analysis assumed, further reducing EDB and EDC emissions from the marketing of leaded gasoline. The commenter further pointed out that the concentrations of these compounds are so minute as to render detection in leaded gasoline vapors virtually impossible, and the nonoccupational exposures are intermittent and brief (I-H-94).

Response: It is true that the small risk associated with exposure to EDB and EDC will decline as leaded gas is phased out of the market place. In the revised analysis, EDB and EDC risk calculations have been dropped. However, as was pointed out in the evaluation report (I-A-55) and Federal Register notice (I-G-15), the Agency believes that there is sufficient evidence derived from human epidemiological studies to support the existence of a causal association between exposure to benzene and the onset of cancer. On June 8, 1977, benzene was listed as a hazardous air pollutant under Section 112. The listing was based on the evidence referred to above, and EPA's finding that ambient exposures to benzene may constitute a cancer risk and should be reduced. Other evidence also implicates gasoline vapors as a possible serious health hazard for humans. The unit risk factor developed for gasoline vapors is based on laboratory studies with mice and rats.

Given the pervasive ozone nonattainment problem and the potential hazardous exposure of millions of gasoline consumers and those living in the vicinity of service stations, the Agency believes that regulation of refueling emissions is warranted. The rationale for the regulatory proposal is contained in the Federal Register notice accompanying this document.

Comment: One commenter felt that new EPA requirements would represent regulatory duplication because OSHA already controls exposure of employees at gas stations (I-H-3).

Response: It is EPA's understanding that OSHA has not taken, and has no immediate plans to take, steps to limit the exposure of service station employees specifically to the vapors generated during refueling operations. Controls on refueling would have multiple benefits, including health risk reduction for employees, self-service (and other) customers, and the community, as well as reductions in ambient ozone concentrations. The extent to which these controls provided beneficial effects for service station employees would not duplicate current benefits conferred by OSHA's occupational standards.

Comment: A commenter felt there is no need to regulate small, rural stations since they do not contribute significantly to air pollution, and they provide a tremendous service to rural communities (I-H-1A6).

Response: It is true that smaller stations located in rural areas contribute a relatively small percentage of overall VOC emissions compared to large, urban stations, and hence are smaller contributors to the ozone problem. In addition, these facilities are generally situated in attainment areas, where control of ozone precursers may not be needed specifically to attain the ambient standard.

Since it is likely that facilities below some particular throughput cutoff would not have to install refueling vapor controls, many of the smaller facilities referred to by the commenter would not be regulated even under possible State initiations. However, uncontrolled facilities in rural areas would be contributing to health impacts, especially during self-service refueling, and so could be controlled just as the stations in urban areas. Individual States may decide to impose a more stringent distribution of Stage II regulatory coverage than that permitted to EPA by the Clean Air Act, based on the environmental, health, and economic impacts of the controls.

Comment: Two Ohio-based petroleum marketers felt that the hydrocarbon emissions from natural sources (i.e., trees, leaves, and shrubbery) are equal to, if not greater than, hydrocarbons emitted by dispensing petroleum products (I-H-1, I-H-1A20). One commenter argued that the current state of knowledge about the cause and effect of ozone levels is insufficient to justify control measures (I-H-1).

Response: The EPA has specific statutory obligations to limit certain sources of air pollution that affect human health or welfare. The fact that plants also produce hydrocarbons that may play a part in pollution in no way changes EPA's responsibility or authority.

While all of the ozone formation mechanisms are not fully understood with certainty, prevailing scientific evidence and opinion has established the link between VOC emissions (such as those from petroleum sources) and the formation of ozone in the atmosphere. Since emissions from the segments of the gasoline marketing industry form a significant portion of total uncontrolled VOC emissions, especially in more populated areas, the Agency decided to evaluate strategies for reducing the adverse environmental and health impacts from this emission category.

The commenter did not suggest any control techniques that would reduce the hydrocarbon emissions from plants. The locations of hydrocarbon emissions from vegetation are generally concentrated in rural areas that are attaining the ambient ozone standard. In addition, natural hydrocarbon emissions generally do not contain compounds that are likely to be hazardous, such as benzene.

Comment: One commenter stated that in light of the uncertainties associated with the API studies, the Agency should move forward on the basis of valid and reliable information currently available (which excludes the API studies), with the provision that its regulatory approach may require supplementation or amendment as additional information is developed (I-H-94).

Response: The Health Effects Institute has recently evaluated the scientific information regarding the human health risk of gasoline vapors (I-A-65). The Institute's conclusion was that although the API animal study was well conducted and demonstrates that some components of gasoline increase cancer rates in rats and mice, its relevance to human risk assessment is uncertain. The Institute also concluded that the available epidemiologic evidence neither negates nor confirms the interpretation that gasoline vapors are a potential human carcinogen. Although the Institute suggested that the lower bound of gasoline vapor risk was equal to zero, the Institute noted that a decision to implement mandatory controls based on available estimates, despite the uncertainty, is a policy question.

The EPA believes that it is appropriate to consider the API studies, as well as other available information, in estimating the potential health risk from gasoline vapors, despite the uncertainties involved. These uncertainties were fully considered when interpreting the results of the risk assessment in order to reach a decision on appropriate regulatory strategies.

6.2 COST/BENEFITS OF CONTROLS

Comment: One commenter stated the nationwide onboard cost and benefits analyses were in error because: 1) the per-vehicle costs were greatly underestimated, 2) the analysis included benefits where Stage II systems are already in place, 3) the analysis ignored the fact that onboard will increase emissions at stations with Stage II, 4) the analysis underestimated spillage, and 5) a large portion of the in-use effectiveness is due to evaporative emission controls that may not occur (I-H-114).

Response:

1) The EPA has reanalyzed its onboard cost estimates in detail. A discussion of these costs by cost category is contained in Section 2.6.

2) An error was discovered in the original analysis of emission reductions, whereby additional Stage II emission reductions were calculated for areas where Stage II was already in place. This error has been corrected in the revised analysis. The cost and incidence calculations in the original analyses correctly considered the areas where Stage II controls are already in place.

3) The impacts of onboard controls at stations already having Stage II controls were considered in the 1984 analysis. These impacts included the lack of control of underground storage tank emptying losses and reduced recovery credits.

4) No data on spillage could be found that were significantly better than the basis of the AP-42 emission factor of 84 mg/l. Therefore, this estimate was used in the 1984 analysis, as well as the new analysis. Table 2-2 of the Draft Volume I RIA summarizes all the emission factors used in the analysis.

5) In the reanalysis, excess evaporative emissions have been considered separately; thus, Stage II and onboard have been compared on an equal basis.

Comment: One commenter felt that EPA's cost-benefit analysis approach seemed reasonable. However, they thought the analysis overlooked or did not address the newer technology Stage II recovery systems and the economic cost recovery mechanisms that exist (I-H-65).

Response: The EPA has re-evaluated Stage II costs and developed cost estimates that reflect currently available systems (see Appendices B and C of the Draft Volume I RIA). No specific economic cost recovery mechanisms were mentioned by the commenter apart from fuel recovery, tax advantage, and credits. These mechanisms were considered for inclusion in the Stage II cost reanalysis.

6.3 ALTERNATIVE CONTROLS

Comment: One commenter opposed to Stage II controls urged the investigation of other control alternatives because there are other solutions that would be technically better, less costly, and have their costs borne more equally (I-H-88).

Response: This commenter did not specify any particular alternatives. The Agency selected for evaluation all feasible regulatory strategies and options it considered appropriate based on initial estimations of costs, technical feasibility, emission reductions, and other factors. Although there are other sources of VOC emissions that are candidates for control, they are not substitutes for refueling control, but complementary parts of the overall strategy to address the pervasive ozone problem.

Comment: One commenter felt that, since onboard controls would collect both refueling and excess evaporative emissions, any comparisons made with Stage II should include the impacts of volatility, or Reid

Vapor Pressure (RVP), limitations on commercial gasoline. (RVP limitation is an alternative to control the evaporative emissions uncontrolled by Stage II.) These added measures should be accounted for in comparing both the costs and the time required to implement onboard and Stage II controls. The commenter noted that the costs of RVP control would include the capital costs of reconfiguring refineries to maintain gasoline quality at lower RVP and the higher cost of lower vapor pressure high octane blending components (I-H-94).

Another commenter suggested that a strategy including Stage II plus extra evaporative emission control (employing an enlarged carbon canister) would be more cost effective than any of the vehicle refueling emission control approaches considered by EPA (I-H-118).

Response: The reanalysis of regulatory strategies performed since the evaluation report was issued in 1984 takes into account the additional strategies of Stage II combi[illegible]ith gasoline RVP limitations, and Stage II combined with enlarged canisters for control of excess evaporative emissions. The impacts of these and the other strategies are discussed in the Draft Volume I RIA and in another EPA report (I-A-66).

Comment: One commenter felt that EPA failed to evaluate the reduction of the volatility of gasoline as a control strategy, despite the substantial impact this measure would have in reducing vapors at every step in the gasoline marketing system (I-H-101). Another commenter stated that controls on commercial fuel volatility are needed to reduce in-use evaporative emissions (I-H-100).

One commenter felt that EPA (through its powers under Section 211(c) of the Act) should encourage all States to adopt and enforce the ASTM Standard D 439 setting volatility limits on gasoline. Some gasolines fall outside of these "good industry practices," and some States (such as New York, New Jersey, and Texas) have not adopted the ASTM limits. The commenter also saw no benefit in EPA's considering any restrictions on gasoline RVP below the limits in the ASTM Standard, because of the resulting disruption in the butane market and the gasoline price increase of 1.5 cents per gallon that would occur during the control period. The installation of Stage II or onboard systems would be preferable as measures to control vehicle refueling or evaporative emissions (I-H-99).

Response: The Agency has evaluated RVP limitations and has proposed a decision along with the onboard proposal. The rationale for these proposals is contained in the respective Federal Register notices.

6.4 REACTION TO GASOLINE PRICE INCREASE (STAGE II)*

The Agency received only four comment letters from the general public concerning price increase; i.e., these commenters were not representing any company, agency, or organizational affiliation. One of these commenters expressed the view that higher gasoline or automobile prices would not be justified unless a more positive link was established between cancer deaths and gasoline dispensing by the public (I-H-28).

Several companies and organizations referred to gasoline price increases in terms of a facility's ability to compete in light of its control costs, and discussed whether these costs could be passed through to consumers. These comments on the economic impacts of Stage II controls are summarized in Section 3.6.

6.5 REACTION TO INCREASE IN PRICE OF A NEW VEHICLE (ONBOARD)*

Comment: Three commenters felt EPA's estimate of an onboard system cost of $15/vehicle to be reasonable and supported by API and ARCO studies. In addition, the commenters believed there was no reliable technical basis for the onboard costs estimated by the automobile manufacturers that are far in excess of those made by API and ARCO (I-H-102, I-H-108, I-H-119).

One commenter felt that the impact of onboard controls was overstated, and that a $15 increase in the purchase price of vehicles whose price tags average upwards of $10,000 will not have any discernible effect on new car sales (I-H-115).

Response: Comparisons of absolute dollar values associated with the cost of control technology and the price of vehicles are not sufficient to determine the effect on buyer behavior of small increases in vehicle price. Price elasticities, which measure the percentage change in quantity demanded due to a 1 percent change in the price of a good, more accurately reflect buyer response to small price changes.

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Since elasticities are intended to capture consumer responses to small price changes, elasticities are used to estimate consumption declines associated with price increases attributed to controls. Since there is disagreement in estimates of vehicle price elasticities, the analysis examines the impacts of vehicle cost increases assuming several different price elasticities. (See pp. 8-22 through 8-26 of the July 1984 Analysis Report.) The analysis reflects market history, which indicates that some behavioral response on the part of buyers will be observed, even when the price increase is small.

Comment: One commenter considered the onboard control system to be an "anti-pollution gizmo" designed to raise the prices of American cars (I-H-7).

Response: Both onboard and Stage II controls are designed to reduce emissions of ozone precursors and hazardous pollutants, and thereby protect the health of the public. As discussed in detail in Section 2.6, the extra cost for onboard controls is estimated to be about $20 for each passenger car (see Table 2-5). This cost to the consumer seems reasonable in light of the environmental and health benefits that would result from the controls. Moreover, an onboard requirement would apply to all cars, both foreign and domestic.

Comment: One commenter thought that, given the option of paying for VOC controls through an increased gasoline price of approximately 1 cent per gallon or $15 per vehicle, the consumer who drives more than 30,000 miles would generally be better off paying an extra $15 per new vehicle. The commenter calculated that, assuming constant dollars and 20 mpg, the $15 increase for onboard would be equivalent to Stage II costs associated with 30,000 vehicle miles. The same commenter noted that, today, most automobiles are purchased on credit. Consequently, if vehicle financing rates and time value of money are taken into account, the one-time onboard cost would be significantly higher than $15 and might not provide any benefit (I-H-126).

Response: As indicated by the commenter's analysis, many variables are involved in determining the relative attractiveness of these regulatory strategies to an individual consumer. These variables include gas mileage, miles driven, length of vehicle ownership, and the credit terms involved in the vehicle purchase. Variations in one or more of these factors may result in greatly differing results.

In the reanalysis, such factors play an even larger role. The latest onboard control analysis projects a per-vehicle onboard control price that varies with vehicle vintage (model year) and posits that captured vapors will improve fuel efficiency and generate recovery credits for vehicle owners. Vehicle vintage, miles driven, length of vehicle ownership, gasoline price, and the rate of time preference (discount rate) determine the credit received by the individual vehicle owner; vehicle vintage and credit terms determine the gross (initial) cost of the control to the purchaser. Accordingly, the net cost of onboard control to the individual consumer will vary with all of these factors.

6.6 REFERENCES (Comment letters are not repeated here. See Chapter 1, Table 1-1, for a complete list of comment letters.)

I-A-55 Evaluation of Air Pollution Regulatory Strategies for Gasoline Marketing Industry. U.S. EPA. Research Triangle park, N.C. EPA-450/3-84-012a. July 1984.

I-A-65 Gasoline Vapor Exposure and Human Cancer: Evaluation of Existing Scientific Information and Recommendations for Future Research. U.S. EPA. Prepared by the Health Effects Institute. September 1985.

I-A-66 Study of Volatility and Hydrocarbon Emissions from Motor Vehicles. U.S. EPA, Office of Mobile Sources. EPA-AA-SDSB-85-5. November 1985.

I-F-78 Air Resources board, State of California. A Report to the Legislature on Gasoline Vapor Recovery Systems for Vehicle Fueling at Service Stations (Stage II systems). March 1983.

I-G-15 Regulatory Strategies for the Gasoline Marketing Industry. Notice of Availability of a regulatory strategies analysis document for public comment. U.S. EPA. 49 FR 31706. August 8, 1984.

7.0 STAGE I CONTROLS*

Comment: One commenter stated that the 1984 cost of a carbon adsorption unit for vapor control at bulk terminals was about 80 percent of the 1981 cost (based on a maximum emission from the unit of 30 mg/l). This change in cost would affect the Agency's bulk terminal control cost estimates (I-H-27).

Response: The reduced cost suggested by this manufacturer was factored into the updated bulk terminal cost analysis. The net effect is a reduction of about 10 percent in the unit purchase cost for carbon adsorption (CA) systems. Since the CA system costs are averaged with thermal oxidizer and refrigeration system costs to determine average bulk terminal control costs, the net effect is a reduction of only about 4 percent in the average unit purchase cost for all vapor recovery systems at terminals.

Comment: One commenter noted that, in Tables 7-8, 7-9, and 7-10 of the July 1984 Analysis Document, "NA" (not applicable) was shown for the product recovery credit for for-hire tank trucks at terminals, for bulk plants, and for service stations using Stage I control. The commenter felt that either he had misunderstood the costing material or that cost credits should be allowed for the vapors saved through controls in each of these cases (I-H-132).

Response: Recovery cost credits are applied in calculating net control costs in two situations: (1) when vapors are condensed into usable liquid product, and (2) when, through the application of controls, product is prevented from evaporating and being lost. The former situation applies at a bulk terminal using a vapor processor to recover the gasoline vapors displaced from tank trucks during the loading operation. Recovered product is piped as a liquid to storage tanks for sale with the regular product. Tables 7-1, 7-2, and 7-4 of the July 1984 Analysis Report show recovery credits for bulk terminals using vapor recovery controls. The latter situation applies in the case of storage tanks and at bulk plants using a vapor balance system. In the case of storage tanks, the recovery credit represents the difference between the emissions from a fixed-roof tank and an internal floating-roof tank. Recovery credits for a bulk plant using vapor balance arise due to the prevention of storage tank emptying losses following the loading of account trucks. Without vapor balance, fresh air is drawn into the storage tank as the tank is drained, and the product subsequently evaporating into this air space is lost through tank venting. With vapor balance, a vapor saturated air space is maintained above the product to suppress evaporation and loss. Tables 7-6 and 7-7 of the July 1984 Analysis Report show recovery credits for bulk plants controlled by vapor balance.

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*1984 Federal Register topic.

As pointed out on page 7-15 of the report, a recovery credit does not accrue to for-hire tank trucks. Vapors drawn into these tanks during vapor balance do not suppress product evaporation and loss (as occurs at a bulk plant using vapor balance) because the truck tank is emptied of product during the vapor balance operation. For this reason, product recovery credits do not apply in the cost calculations shown for for-hire tank trucks in Tables 7-8 and 7-9 of the July 1984 Analysis Report. In the case of service stations, the displaced vapors are lost from the underground tank regardless of whether Stage I is in use or not. Therefore, Table 7-10 does not apply a recovery credit in presenting the costs associated with Stage I control at service stations. Finally, credits are allowed for Stage II for reasons similar to those given above for a bulk plant using vapor balance.

8.0 EFFECTS ON STATE IMPLEMENTATION PLANS (SIP's)*

The EPA received numerous comments on the effect of gasoline marketing controls on State regulations, particularly the feasibility of the States' incorporating Stage II or onboard controls into their respective SIP's. This section summarizes their comments and EPA's responses to the following issues:

- Ozone NAAQS Attainment Deadline
- Emission Credits
- Effect of State Adoption of Controls
- EPA's Role in Selecting Controls
- Miscellaneous Other Issues

8.1 OZONE NAAQS ATTAINMENT DEADLINE

Many commenters expressed concern about the States' meeting the December 1987 deadline for implementing controls. These commenters were also concerned with EPA's schedule for deciding whether to regulate VOC emissions from refueling operations.

Comment: A number of commenters stated that EPA should decide promptly whether further gasoline marketing controls are required because States are actively searching for options to meet the approaching 1987 NAAQS deadline. In this regard, some commenters suggested that EPA select onboard and stem any move by the States toward Stage II (I-H-99, I-H-102, I-H-108, I-H-109, I-H-119). One of these commenters stated that it is important for EPA to define promptly the role of hydrocarbons in oxidant formation before States with nonattainment areas revise their implementation plans by the December 31, 1987, deadline. The commenter pointed out that if EPA fails to act in a timely manner, industry could be faced with the needless implementation of Stage II vapor recovery systems, possibly even duplicating other systems for control of vehicle refueling emissions (I-H-99).

In contrast, other commenters felt EPA should not delay in issuing guidance on implementing Stage II controls (I-D-56, I-H-21, I-H-100). One felt that a Stage II regulation would bring the nation closer to achieving the ozone NAAQS by the 1987 deadline (I-D-56). Another commenter stated that States are ready to implement Stage II, noting that seven States have already proposed to use Stage II controls to meet ozone standards in certain areas and that their initiative should not be discouraged (I-H-100). One State supporting a national onboard control program said that it is proceeding with implementation of Stage II as the only option available to control refueling emissions on a short-term basis (I-D-65).

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*1984 Federal Register topic.

According to one commenter (I-H-92), a decision is needed soon on whether to regulate VOC emissions from motor vehicle refueling in order to: (1) provide guidance to States that have been directed by EPA to revise ozone SIP's to adopt additional VOC control measures by the end of 1987; and (2) give States time to determine what, if any, regulatory approach they should adopt to control benzene emissions from motor vehicle refueling in areas other than those that are nonattainment for ozone, if a national regulation requiring Stage II controls in urban ozone nonattainment areas is adopted by EPA.

Response: The Agency is proposing to regulate vehicle refueling emissions by means of onboard controls. This will result in effective long-term reduction of refueling emissions, and nationwide protection from exposure to benzene and other potential carcinogenic constituents in gasoline. Because of the time necessary to phase in onboard controls, however, the Agency has evaluated other Federal requirements that could provide near-term VOC reductions. As a result, EPA also is proposing to limit in-use fuel volatility which will produce substantial reductions relatively quickly. The EPA also considered requiring Stage II controls in some ozone nonattainment areas as an interim measure until onboard controls become effective. However, EPA proposes not to impose Stage II as a requirement in those areas where it is not now being implemented or is not contained as a commitment in a State Implementation Plan (SIP). Nevertheless, States may choose to adopt Stage II controls as an appropriate VOC control measure in such areas where it is not now implemented or committed to, depending on a case-by-case assessment of local ozone nonattainment problems and available VOC control alternatives.

Comment: One commenter stated that EPA should defer any action requiring States to adopt controls on VOC emissions from motor vehicle refueling in ozone nonattainment areas until a final national policy has been established, and specifically, Stage II controls should not be required until this form of control has been defined as reasonably available control technology (RACT). The commenter felt that a requirement for action prior to such time would be unwarranted (I-H-92).

Response: As discussed in the accompanying *Federal Register* announcement concerning proposed onboard controls and in other responses, the Agency does not intend to require Stage II controls in all nonattainment areas. However, Stage II can be effective in particular situations, and is an available measure for States to consider in revising their implementation plans applicable to ozone nonattainment areas. The EPA will support such efforts made by the States where analysis indicates it is a desirable alternative for ozone control.

Comment: Two commenters suggested that EPA continue to focus on the 16 original target AQCR's (all of which already have Stage II). They felt no nationwide Stage I and Stage II measures should be considered until meaningful, reasonable procedures for the 16 AQCR's are developed (I-H-42, I-H-43).

Response: The problem of ozone nonattainment clearly extends beyond some "16 original target AQCRs" in which Stage II is now in place. There are more than 60 major urban areas outside of California, containing over 80 million people, which have ozone levels significantly above the national ambient air quality standard. The Agency considers the problem of ozone nonattainment to be a serious national concern requiring a broad-based solution, of which the proposals for onboard controls and reduction of fuel volatility are only a part.

Comment: Some commenters expressed concern about EPA's implementing Stage II or onboard controls in time to meet the 1987 deadline (I-D-54). One commenter estimated that the phase-in period for Stage II implementation would be 7 years, rather than 2 years; therefore, implementation would not be faster than onboard (I-H-83). Other commenters stated that Stage II vapor recovery systems cannot reasonably be expected to be implemented in most nonattainment areas by the 1987 deadline (I-H-99, I-H-102, I-H-119, I-H-124). One of the commenters stated that 6 years would be required to complete installation in nonattainment areas (I-H-99). According to another commenter, a minimum of 2 years would be required for the State (Pennsylvania) to develop and adopt Stage II requirements, and another 2 years or more would be needed to actually install the equipment (I-H-122). Another pointed out that it would take his State (Virginia) close to a year to adopt and implement a Stage II regulation (I-D-53).

Response: To determine the phase-in period for Stage II implementation, EPA considered in its reanalysis a range of periods from 3 years to 7 years. A number of commenters believed that 3 years would not be enough time for all regulated businesses to install Stage II controls, maintaining that there would not be a sufficient number of installation contractors to perform the necessary work in 3 years. For that and other reasons, EPA included an evaluation of a 7-year phase-in period in the examination of a nationwide Stage II program. However, since Stage II controls would be implemented on a smaller scale when considering controls only in nonattainment areas, EPA believes that a somewhat shorter period could be achieved. Therefore, EPA used a range of phase-in periods in evaluating Stage II controls in nonattainment areas in the reanalysis. A more complete discussion of control strategy phase-in issues is contained in Section 2.5.

Comment: Two commenters favoring onboard urged that EPA delay the 1987 ozone attainment deadline or grant SIP extensions for reduction shortfalls, since neither Stage II nor onboard would allow timely attainment of the NAAQS for ozone (I-H-37, I-H-60).

Response: The EPA has no authority to delay the 1987 ozone attainment schedule, which is provided for in the Clean Air Act. However, the Agency recognizes that a number of areas will not attain the standard by the specified deadline and plans to develop a comprehensive post-1987 ozone policy to deal with the need for revised SIP's and adoption of additional and more aggressive VOC control measures.

8.2 EMISSION CREDITS

A number of commenters felt that emission credits (i.e., an allowance for future reductions) should be given for Stage II and onboard controls since implementation may not occur by the 1987 deadline.

Comment: Several commenters favoring the onboard control approach suggested that, since neither onboard nor Stage II controls could be implemented in sufficient time for States to achieve the ozone standard by the December 31, 1987 deadline, EPA should grant advance SIP credits for onboard controls, recognizing the delayed impact of this control strategy (I-D-55, I-H-44, I-H-84, I-H-85, I-H-87, I-H-97, I-H-102, I-H-105, I-H-106, I-H-109, I-H-110, I-H-121, I-H-122, I-H-123). According to several of these commenters (I-H-85, I-H-87, I-H-102), such a policy would give flexibility to the States, and would eliminate the need for temporarily implementing Stage II controls.

Four commenters who recommended onboard controls stated that it is not necessary for the selected control measure to be fully implemented by the attainment deadline because EPA has the authority to approve revised SIP's for ozone nonattainment areas which anticipate controls that will be fully implemented by December 31, 1987 (I-H-98, I-H-108, I-H-109, I-H-119). Two of these commenters further stated that EPA should not create the impression that the controls necessary to achieve the desired VOC reductions must be in place by the end of 1987 but rather the reductions must be "provided for". The Agency's attainment policy and guidelines adopted for its implementation allow EPA to approve a commitment to onboard without requiring additional Stage II measures in the interim to offset the effects of any delayed capture of emissions (I-H-108, I-H-119).

One commenter (I-H-94) added that if EPA required onboard controls, the Agency should then conduct analyses comparing other available short-term, interim control strategies to be used as guidance by individual States needing additional VOC emission reductions to attain the NAAQS.

One commenter stated that, for judging nonattainment status, credits should be given for hydrocarbon emission reductions that will occur after 1987 through programs implemented prior to that date (I-H-99).

Response: It is apparent that many areas will not attain the ozone standard by the 1987 deadline. Thus, the commenters' concerns about whether measures have been "implemented" or "provided for" in SIP's for such areas can be better addressed by considering whether the SIP's contain measures sufficient for expeditious attainment of the standard. As discussed earlier, the Agency is developing a post-1987 ozone policy which addresses the need for calls for revised SIP's, the range of activities to be covered in SIP revisions, and the need for adequate demonstrations of progress toward attainment. As part of the strategy development process, the Agency has evaluated a broad range of potential VOC control measures and will work with the State and local agencies in the development of reasonable, effective programs for expeditious ozone standard attainment.

Comment: One commenter believed that implementation of controls would not achieve emission reductions until after the 1987 deadline and, therefore, the regulations could be considered unnecessary (I-H-122).

Response: The EPA agrees that neither Stage II nor onboard controls can be implemented in time to meet this deadline. However, nonattainment area control strategies still will be needed even after the deadline passes. The statutory requirement to attain the ozone standard will still exist after December 1987.

Comment: One commenter stated that onboard provides significantly more emission reductions than Stage II at roughly the same costs, and emphasized that the most cost-effective control measure should be implemented first (I-H-98).

Response: As described in the preamble, there were a variety of factors that led to the proposal of onboard as the most desirable refueling control technology. One of those factors was the projection that onboard, when fully implemented, would likely achieve greater emission reductions, and cover more refueling events than would Stage II.

Comment: One commenter felt that EPA's calculation of net present value estimates of costs and benefits over a 35-year period obscures the fact that Stage II controls would reduce hydrocarbon emissions in time to improve air quality by the 1987 deadline (I-H-114).

Response: The analysis period of 35 years was used to compare strategies with different phase-in times more objectively. It was noted that Stage II could possibly get in place earlier than onboard, but not likely on a national basis before the 1987 deadline. Careful consideration was given to targeted Stage II versus onboard. On the basis of the broad range of benefits associated with onboard, and the pervasive, long-term nature of the ozone problem, the Agency decided to propose onboard as the most desirable refueling control option (see the Federal Register notice for additional discussion).

8.3 EFFECT OF STATE ADOPTION OF CONTROLS

Comment: Five commenters indicated that EPA should discourage the piecemeal promulgation of Stage II by the States in their SIP's since a State-by-State "creep" adoption of Stage II would eventually result in a nationwide Stage II program. Pennsylvania was cited by one commenter as an example of Stage II "creep," where State regulations would require Stage II controls essentially statewide rather than in only the nonattainment portion of the State (I-H-102, I-H-108, I-H-109, I-H-119, I-H-120). All of these commenters suggested that EPA select onboard controls instead of Stage II if further gasoline marketing controls are required. One of them believed that States would consider Stage II controls as their only available alternative (I-D-54, I-H-120).

Another commenter preferred onboard because its broader coverage would make it more effective than area-targeted Stage II controls. Also, area-targeted Stage II would almost certainly expand into additional areas as attainment areas were reclassified to nonattainment, or as States applied the regulations statewide in the interest of equity or administrative simplicity. This would undermine the apparent cost effectiveness of a Stage II program that was originally targeted to nonattainment areas (I-H-83). A second commenter also pointed out that, due to the shifting nature of ozone attainment, States often effectively turn a nonattainment area strategy into a statewide requirement. In this way, nonattainment area strategies can tend to become equivalent to nationwide programs. This commenter felt the use of onboard canisters would effectively address the issue of "shifting or spreading" nonattainment areas (I-H-24).

Response: States have the authority, in most cases, to prescribe controls that are more stringent than Federal regulations require. If a State chooses to require a control strategy statewide that EPA would require in nonattainment areas only, or that EPA has not required at all, that State effectively is enacting more stringent controls than those required by EPA. States may implement such control strategies if they deem them necessary to reduce ozone and protect the public health and welfare.

However, given that EPA has proposed to require onboard technology on new vehicles, which will eventually make Stage II unnecesssary, it is doubtful that the "creep" issue will become a major problem. Even those States that adopt Stage II as an interim strategy are likely to target the requirement to existing problem nonattainment areas.

Comment: Several commenters from State control agencies noted their commitment or lack of commitment to adopt or investigate Stage II controls. One commenter thought EPA's statement, that several States had "made commitments to adopt Stage II" as part of their strategy to attain ozone goals by 1987, was not entirely correct. This State agency (and others) had committed to study various alternatives and adopt the best choice. The commenter believes such State efforts would be compromised by an EPA decision to adopt onboard nationwide, unless the attainment deadline is changed (I-H-21). Another State agency felt EPA should hold States to their original SIP commitments where necessary to achieve the ozone standards (I-H-65).

One commenter indicated that they had committed to investigate Stage II controls in the Pennsylvania 1982 SIP revisions for ozone. However, until EPA makes a decision on whether to require onboard canisters, the commenter believed it is unlikely that Stage II regulations will be adopted (I-H-122).

Response: As noted in earlier comments, EPA has evaluated Stage II as an interim VOC control measure, and expects areas with Stage II in place (or in the process of being installed) to continue to maintain the system until such time as it is effectively made unnecessary by onboard-equipped cars and the appropriate SIP revisions are approved. In addition, EPA expects States with existing commitments in their SIP's to implement Stage II to do so unless they can identify adequate substitute measures and include such measures in approved SIP revisions. The EPA recognizes that not all references to Stage II in an implementation plan constitute a "commitment." However, it must be realized that even though a given plan may have committed only to study the measure as a possibility if further VOC reductions proved necessary, many areas will probably need such reductions. If Stage II is determined to be impractical in areas where it has not yet been implemented in terms of timing, cost-effectiveness, or other selection criteria, the necessary reductions nevertheless will have to be made up by available but perhaps equally difficult choices.

Comment: One commenter stated that if EPA demonstrates that control of refueling vapors is necessary and a cost-effective way for States to meet oxidant standards, then controls should be required only in areas projected to be nonattainment at the 1987 deadline (I-H-99).

Response: Onboard is being proposed as the refueling control strategy because, among other things, of greater overall benefit potential, simplicity of administration and use, and cost effectiveness. The proposal of onboard also reflects concern for the future of marginal attainment areas (i.e., a need to maintain satisfactory air quality). Also, onboard achieves emission reductions in areas surrounding nonattainment areas, which contribute to violations of the ozone standard.

8.4 EPA'S ROLE IN SELECTING CONTROLS

The EPA received several comments about EPA's role in selecting gasoline marketing controls.

Comment: Two commenters questioned EPA's role in selecting gasoline marketing controls and recommended instead that the decision to select controls should be delegated to the States. One of these commenters (I-H-91) felt that EPA should not issue a Control Techniques Guideline covering Stage II, but should leave the flexibility of choosing the most cost-effective controls with the States. The second commenter (I-H-94) stated that it is more appropriate for each State, rather than EPA, to conduct an analysis of the unique problems of each nonattainment area and then to develop a specific control strategy for that area based on a range of available control techniques. The commenter added that EPA's role should be to analyze the pros and cons of all possible ozone control techniques and provide guidance to the States in their individual SIP revisions.

Another commenter stated that EPA has both the legal and moral authority to guide States in choosing the most appropriate control strategy so that States do not mistakenly implement short-term, less cost-effective controls that would be obsolete in several years (I-H-98).

Response: As stated before, the Agency sees the ozone problem as pervasive and long-term and there is much to be done by both the EPA and the States. The EPA believes that vehicle refueling should be controlled nationally, using onboard controls, because of the broad basis of the ozone nonattainment problem, and because of the potential for exposure to hazardous emissions. The Agency is also proposing to regulate volatility, which will have national ozone benefits. The Agency feels that it is best left to the States to adopt, as needed, a range of other measures based on local needs.

8.5 MISCELLANEOUS

Comment: One commenter noted that the July 1984 analysis listed only 10 counties in Ohio as potentially subject to Stage II, while 26 counties are currently listed as nonattainment for ozone (I-H-24).

Response: The July 1984 EPA analysis evaluated two nonattainment area groupings. One contained all nonattainment areas given an extension to 1987 for achieving the standard. This grouping contained 10 Ohio counties. The other grouping, called "selected nonattainment areas," was a subset of the extension areas and consisted of areas where a commitment was contained in their SIP to evaluate Stage II as an additional means of achieving the ozone standard. No Ohio counties were included in this grouping.

In the new analysis, the nonattainment area evaluations centered upon three area groupings (11, 27, and 61 areas). The 11-area grouping consisted of 11 metropolitan areas most likely to need refueling control, based on design levels and estimated ozone shortfalls. The 27-area grouping consisted of areas that were predicted to continue to be nonattainment in 1987 and currently do not require Stage II. Neither of these two groupings contain any Ohio counties. The-61 area grouping consisted of non-California areas that recorded design values greater than the ambient ozone standard (0.12 ppm) in 1982-1984. This grouping contained 19 Ohio counties. Therefore, the number of Ohio counties considered in the analysis is dependent on the definition of nonattainment areas used. [When EPA considered all designated nonattainment areas, the grouping included 27 Ohio counties.]

9.0 EXPOSURE/RISK ANALYSIS

9.1 UNIT RISK FACTORS

Comment: One commenter noted that, using the information developed in the evaluation, one cannot conclude that the control options discussed are reasonably available or cost effective. However, if one were to take into account the exposure of gasoline service station workers and also to factor in new information on benzene exposure coming out of California, this conclusion may change. For example, cancers from benzene exposure may be as much as three times higher than EPA has originally reported (reference: Health Effects of Benzene, Part B, California Department of Health Services, Epidemiology Section, July 1984) (I-H-65). Another commenter asserted that EPA's 1981 assessment of benzene risk did not take into account a number of important studies showing that benzene causes other forms of cancer in addition to leukemia and that the unit risk factor should be increased by as much as 15-fold (I-H-115).

Response: The unit risk factor for benzene has been re-evaluated and increased in light of new information, in part contained in the July 1984 report from California (I-F-103). The new benzene risk factor, which is 17 percent higher, was used in the reanalysis. Occupational exposures of service station workers to benzene and gasoline vapors were approximated in the revised analysis from time-weighted averages taken from a Shell Oil industrial hygiene study (I-F-13). These new exposure situations were considered in the reanalysis of occupational and lifetime risk.

Comment: One commenter opposed the listing of benzene as a hazardous air pollutant under Section 112 and argued that the EPA assessment of unit risk is inflated (I-H-120). Another commenter noted that EPA has calculated a unit risk factor for benzene based on information gathered during a separate rulemaking on benzene (49 FR 23478). This benzene rulemaking was controversial, and was challenged by many commenters as significantly overestimating cancer risks (I-H-101).

Response: The Clean Air Act defines hazardous air pollutants under Section 112 as those substances judged to cause or contribute to air pollution "which may reasonably be anticipated to result in an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness."[1] EPA based the decision to list benzene on a growing consensus in the scientific and regulatory community, as evidenced by reports by the National Academy of Sciences,[2] the National Institute for Occupational Safety and Health,[3] and proposed regulations issued by the Occupational Safety and Health Administration,[4] that benzene was causally linked to the occurrence of leukemia in occupationally exposed populations. In EPA's judgment, leukemia clearly fits the criteria described in Section 112 as a "serious irreversible, or incapacitating reversible, illness."

The EPA's judgment that benzene present in the ambient air could "reasonably be anticipated" to pose a significant health hazard to the general population relied on two arguments advanced in the listing notice: first, that benzene is released to the air at a rate of as much as 260 million pounds annually to which "large numbers of people are routinely exposed" and, second, that EPA had "adopted a regulatory policy which recognizes that some risk exists at any level of exposure to carcinogenic chemicals."[5]

Based on the above, EPA believes that the decision to list benzene was appropriate. The subsequent assessments of low-level exposure and carcinogenic risk were intended, as indicated in the listing notice, for use in "determining which sources of benzene emissions must be controlled, and the extent of control needed."[6]

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[1] 42, U.S.C., 7412(a)(1).

[2] National Academy of Sciences, Health Effects of Benzene: A Review. Washington, D.C., June 1976.

[3] National Institute for Occupational Safety and Health, "Update Criteria and Recommendations for a Revised Benzene Standard," September 1976.

[4] Occupational Safety and Health Administration, "Occupational Exposure to Benzene, Emergency Temporary Standards," 42 FR 22516 (May 3, 1977).

[5] U.S. EPA, "Addition of Benzene to List of Hazardous Air Pollutants," 42 FR 29332 (June 8, 1977).

[6] 42 FR 29333 (June 8, 1977).

Comment: Four commenters pointed out that the Science Advisory Board's (SAB) review of the June 1984 EPA Staff Report entitled "Estimation of the Public Health Risk Exposure to Gasoline Vapor Via the Gasoline Marketing System" concluded that the reported unit risk factor for gasoline vapors was not suitable for quantification of human risk and that the EPA Staff Report should not be used as a basis for regulation. The commenters asserted that the SAB was critical of the Staff Report for its selective approach to inclusion of epidemiological studies and its failure to reveal the uncertaincies inherent in the available data (I-H-101, I-H-102, I-H-117, I-H-127).

Two other commenters reiterated three arguments as to why the existing gasoline vapor health effects data base does not provide an adequate basis for developing a quantitative risk assessment suitable for regulatory decisionmaking: (1) there are fundamental biological uncertainties as to the relevance for humans of the animal models in the API studies; (2) both the chemical mixture and type of exposure in the underlying study differ significantly from real world human experience; and (3) the EPA risk estimates have not been supported by the available epidemiological studies. Thus, they claimed that extensive modifications in the development of the unit risk factor should be made to take into account the purportedly substantial, fundamental, uncertainties. At a minimum, they felt EPA should clearly characterize the uncertainties in the unit risk factor. They considered their opinions to have been confirmed by the SAB (I-H-120, I-H-91).

Response: There were two reasons for the reservations expressed by the SAB. The first reason was that the vapor and whole gasoline may differ in the concentration of carcinogenically active components. This issue will be discussed in a later response. The second reason concerns the biological relevance of the male rat kidney response. However, as discussed earlier in this document, the Agency believes that it is appropriate to consider this evidence of animal carcinogenicity as indicative of a potential risk to human health unless convincing evidence becomes available showing that both the male rat kidney and female mouse liver carcinogenic responses are anomalous. This issue is discussed in more detail later in this document.

Comment: Several commenters expressed concern that EPA recognize and acknowledge the uncertainties associated with the API exposure studies (I-D-54, I-D-63, I-H-94, I-H-101). These commenters referred to API's ongoing research to resolve the questions raised by the original studies. They felt that the current risk factors should be considered preliminary, and that further research using representative gasoline vapors, as well as additional epidemiological studies, may allow an acceptable unit risk factor to be established in the future.

The API briefly described its current ongoing health effects research as having three parts: (1) to determine whether the rat is an appropriate model for assessing effects in humans, (2) to observe the nephrotoxic potential of various components or fractions of unleaded gasoline, and (3) to acquire exposure and health data on occupationally exposed populations. Results to date, according to API, suggest that a significant human health risk is unlikely; however, a decision for the onboard canister would represent a prudent action in light of present uncertainties, and would also control the known benzene health hazard associated with gasoline operations (I-D-54).

Response: The uncertainty in the risk assessment based on the API study is discussed in considerable detail in a later response. Included in the discussion are differences in composition between a liquid aerosol of unleaded gasoline and a saturated vapor, the likely effects of this difference upon the results, the relative contribution of benzene to the carcinogenic response, and the validity of rat kidney tumors and mouse liver tumors for extrapolation to humans.

The commenters imply that EPA should wait for an extended period of time before making the judgment as to whether gasoline vapors present a serious risk of cancer. However, the Agency believes that human exposure to these vapors can have serious health consequences. The precise quantitative measure of health risk calculated in the analysis is secondary to the possibility that these health effects may be actually occurring.

Comment: One commenter felt that data are insufficient to conclude whether benzene levels below 10 ppm result in leukemia (I-H-101). Two other commenters stated that several studies indicate a nonlinear relationship between risk and exposure duration, rather than a linear relationship for benzene. This error could inflate the risk analysis by 2 to 5 orders of magnitude (I-H-114, I-H-127).

Response: Because a specific environmental carcinogen is likely to be responsible for at most a small fraction of a community's overall cancer incidence and because the general population is exposed to a complex mixture of potentially toxic agents in their daily lives, it is currently not possible to directly link actual human cancers with ambient air exposure to chemicals such as benzene. Today's epidemiologic techniques are not sensitive enough to measure a direct association. Therefore, EPA must rely largely upon mathematical modeling techniques to estimate human health risks. These techniques, collectively termed "quantitative risk assessment," are the means whereby the risk of adverse health effects from exposure to benzene in the ambient environment can be estimated mathematically; for example, effects found at higher occupational exposure levels can be extrapolated to lower concentrations characteristic of human exposure in the vicinity of industrial sources of benzene. The analysis estimated the risk of cancer at various levels of exposure. A unit risk factor for benzene is derived from the dose-response relationship observed in the occupational studies. The unit risk factor represents the cancer risk for an individual exposed to a unit concentration of a carcinogen (e.g., one part per million (ppm)) for a lifetime.

In the evaluation of benzene emissions from the gasoline marketing system, EPA has given great weight to the nature and relative magnitude of potential public health risks. In the absence of scientific certainty, regulatory decisions must be made on the basis of the best information available. For benzene, this is represented by the epidemiologic studies of the occupationally exposed population. The association between benzene exposure and human leukemia is given strength by the fact that leukemia mortality rates were observed among independent studies in different occupational settings by independent investigators. The epidemiological studies showed a 3-fold to 20-fold increase in risk of leukemia above that of individuals not exposed to benzene. These findings present unequivocal evidence that chronic inhalation of benzene causes leukemia in humans.

Comment: Several comments concerning the linear, non-threshold dose-response model were received. One commenter felt that the gasoline vapor unit risk factors may not be valid for dose levels outside the range of 60 to 300 ppm, based on the male rat data and a monotonically decreasing gradient with incremental dose level. This suggests dose saturation and questions a linear estimation of unit risk. In addition, the commenter felt that both the male rat and female mice data are inadequate for a valid estimation of true dose-response for low level exposure (I-H-114).

Another commenter stated that the unit risk factors are based on a nonthreshold, linear dose-response model which assumes that even one molecule of a carcinogen presents a finite risk of a cancer. This model has not been validated biologically for benzene or gasoline vapors and is quite "conservative" since it always predicts cancer no matter how small the exposure (I-H-101). One commenter did not question the established risk assessment assumptions, e.g., linearity at low dose levels, nonthreshold for carcinogenicity, and plausible upper limits, since they are conservative estimates of risk. The commenter felt protection of the public health requires the application of these methodologies (I-H-126).

Response: While EPA agrees that the linear, nonthreshold model is conservative in nature and would tend to provide a reasonable upper bound to the statistical risk range, the Agency does not believe that the assumptions upon which it is based are unreasonable nor that the results of its use are exaggerated. The dose-response model with linearity at low dose was adopted for low-dose extrapolation by EPA because at the time of its introduction, it had the best, albeit limited, scientific basis of any current mathematical extrapolation model.

The risk estimate for gasoline vapor represents an extrapolation below the dose range of experimental data. There is currently no experimental basis for any mathematical extrapolation model that relates exposure to cancer risk at the extremely low concentrations that must be dealt with in evaluating environmental exposures. For practical reasons the correspondingly low levels of risk cannot be measured directly either by animal experiments or by epidemiologic studies. Low-dose extrapolation must, therefore, be based on current scientific understanding of the complex mechanisms of carcinogenesis. At the present time the dominant view of the carcinogenic process involves the concept that most, but not all, cancer-causing agents also cause irreversible damage to DNA. This position is based in part on the fact that a very large proportion of chemicals that cause cancer are also mutagenic. There is reason to expect that the quantal response that is characteristic of mutagenesis correlates with a linear nonthreshold dose-response relationship. Indeed, there is substantial evidence from studies with both ionizing radiation and a wide variety of carcinogenic chemicals that this type of dose-response model is the appropriate one to use. This is particularly true at the lower end of the dose-response curve; at high doses, there can be an upward curvature, probably reflecting the effects of multi-stage processes on the biologic response.

The linear nonthreshold dose-response relationship is also consistent with the relatively few epidemiologic studies of cancer responses to specific agentst that contain enough information to make the evaluation possible. Examples of such agents include radiation-induced leukemia, breast and thyroid cancer, skin cancer induced by arsenic in drinking water, leukemia induced by benzene, and liver cancer induced by aflatoxins in the diet. Some supporting evidence also exists from animals experiments, such as the initiation stage of the two-stage carcinigenesis model in rat liver and mouse skin.

Because its scientific basis, although limited in some respects, is the best of any of the current mathematical extrapolation models, the nonthreshold model, which is linear at low doses, has been adopted by EPA as the primary basis for risk extrapolation to a low levels of the dose-response relationship. The cancer risk estimated with the nonthreshold model should best be regarded as conservative and representing a plausible upper limit for the cancer risk (i.e., the true cancer risk is not likely to be higher than that estimated, but it could be lower) when extrapolating from animal studies.

The quantitative aspect of carcinogen risk assessment for gasoline vapors is best used in the regulatory decisionmaking process in deciding whether a need exists for Federal regulation, or in evaluating the adequacy of technology-based controls. Risk assessment is best construed as a relative indication of likely risk. The linear extrapolation model used provides an approximate but plausible estimate of the upper limit of risk from exposure to a unit concentration of gasoline vapor (i.e., with this model it is not likely that the true risk would be much more than the estimated risk, but it could be considerably lower).

Comment: Four commenters criticized EPA's two unit risk factors for gasoline vapors, which were based on the mouse and rat data from the API gasoline inhalation study. The API work used wholly volatilized unleaded gasoline, not gasoline vapors. Thus, the test animals were exposed to all components of the gasoline, and not just the lighter ends that would evaporate during refueling. The API approach seriously overrepresented the heavier fuel components, which are more likely to be carcinogenic (I-D-51, I-D-63, I-H-101, I-H-116, I-H-117). One commenter questioned the relevance of administering a totally evaporated gasoline vapor mixture continuously for hours as compared to an ambient gasoline vapor associated with intermittent exposure for a short time, followed by a long period without exposure, as is the case with self-service gasoline distribution. This commenter remarked that an error in the exposure estimate or health effect will influence the cancer risk factor to a considerable degree. This commenter also noted that high boiling point gasoline fractions are the most mutagenic and carcinogenic in short-term bioassays and animal studies. Thus, the carcinogenic potency of the actual mixtures to which the population is exposed may be entirely different from that calculated from the animal study. Another animal study cited in the EPA Staff Paper indicated high carcinogenic potency in the lighter fractions. The commenter stated that contradictory health impacts lend a greater uncertainty to the animal study results. Therefore, actual carcinogenic potency may be overstated or understated (I-H-126).

One commenter felt that the lifetime risk from high exposure for self-service ("traveling salesmen" case) is only 0.0005 times that of a petroleum worker. The commenter suggested that EPA's estimate of unit risk may be overstated if the transient nature of the self-service exposure is taken into account (I-H-114).

Another commenter pointed out that EPA used the results from an API study employing wholly vaporized gasoline and applied them to exposure data generated during typical self-service refueling operations (referred to as the Clayton project). The commenter stated that the Clayton project does not properly identify the composition of the gasoline vapors. The commenter also pointed to a joint study conducted by Amoco and Shell that showed the composition of gasoline vapor emitted in vehicle refueling to be substantially different from the totally vaporized gasoline administered in the API study. For example, the totally vaporized gasoline administered in the API study contained 151 identifiable compounds, of which 42 accounted for 75 percent of the mixture. In contrast, the Amoco and Shell data reveal that workplace vapor exposures comprise about 20 components (of greater than 0.5 percent by weight or volume) that account for at least 85 percent of the sample. Of these, four C4/C5 hydrocarbons: n-butane, isobutane, n-pentane, and isopentane, comprise 67 percent of the gasoline vapor. Also, the Clayton data reveal that the proportion of various constituents measured were very similar and, in some cases, almost identical to the proportions Amoco and Shell found. The commenter further pointed out that these four hydrocarbons are not known to be either nephrotoxic or carcinogenic. For these reasons, the commenter contended that EPA's use of total hydrocarbon exposure in the risk analysis is faulty (I-H-99).

One commenter stated that the use of the API gasoline studies is not appropriate as a basis for regulation of gasoline vapors because: (1) the test animals were exposed to wholly vaporized gasoline - an exposure totally unrepresentative of anything experienced by humans; (2) potentially the most significant outcome of the studies - an elevated incidence of kidney tumors found in male rats - is questionable due to the apparently unique susceptibility of the male rat kidney to hydrocarbon vapors; and (3) the other significant outcome - an elevated incidence of liver tumors in female mice - is also open to question, since this type of tumor is known to occur spontaneously in laboratory mice at a highly variable, and therefore unpredictable, rate. The commenter concluded that since occupational exposures are shown to involve only a mildly increased cancer risk, the risk to the general population is likely to be negligible (I-H-94).

Response: The fraction of gasoline shown to be responsible for subchronic pathological effects in the kidneys of rats included primarily branched chain aliphatic hydrocarbons having 6 to 9 carbon atoms ("C6-C9"). The relative percentages of these compounds in gasoline vapors versus whole gasoline varies depending upon temperature and other conditions, but on the average, vapors contain about 25 percent as much of these compounds as aerosolized whole gasoline. If it is assumed that the C6-C9 fraction is also responsible for tumorigenic activity, then the risk from the vapors could be as low as about 25 percent of the risk previously estimated.

The claim that the C6-C9 branched chain hydrocarbons are responsible for cancer induction is based upon the hypothesis that tumor induction is a result of renal nephropathy. However, this hypothesis is unproven. In fact, the presence of liver and renal tumors in mice without accompanying pathology, and renal tumors in some rats without mineralization of the renal pelvis, suggested that tumorigenesis is not necessarily preceded by pathology. Therefore, to assume that gasoline vapor is less carcinogenic than an aerosol of whole gasoline, and to make a quantitative adjustment based upon this assumption, would result in the possibility of underestimating risk.

The quantitative estimate of risk was based upon experiments from animals enclosed intermittently, i.e., during the work day instead of 24 hours/day. While it is true that humans are normally exposed for much shorter periods, except for occupational conditions, it cannot be assumed that short exposure periods are necessarily less harmful. For example, exposure to ozone for 8 hours/day results in almost as much lung damage as exposure to the same concentration for 24 hours/day. In this case, extropolation of the risk from shorter exposure using estimates derived from continuous exposure (based on the product of time and concentration) could greatly underestimate risk from shorter exposures.

Under EPA's Proposed Guidelines for the Assessment of Carcinogenic Risk, the induction of liver tumors in mice is considered to be as valid as any other tumor response in animals as evidence for carcinogenicity, unless the response which occurred is weak in one or more of several ways specified in the guidelines. The spontaneous rates in mice were not high enough to throw the results into question. For gasoline, the API study showed carcinogenic effects in both rats and mice, so that a categorization of sufficient evidence in animals is warranted.

Comment: One commenter criticized several of the research methods used in the API study, as follows: (a) The low air exchange rate increased the ammonia, CO_2, and CH_4 concentrations in the exposure booth; since the exposure atmosphere was controlled via the total hydrocarbons only, and no background measurements were conducted in the control booth, one cannot differentiate between the methane emitted by the test animals and the hydrocarbons in the evaporating gasoline; (b) temperature and relative humidity in the booths were not maintained (test conditions were 21° to 29°C and 15 to 92 percent RH, while the OECD-GLP guidelines recommend 22 ± 2°C and 30 to 70% RH); (c) it cannot be judged whether the produced gasoline vapor is comparable to the emissions that occur during fueling and/or operation of vehicles; (d) the amount of aromatics and the benzene concentration in the exposure atmosphere must be measured, not just the total hydrocarbons; and (e) 20 percent of the mice died during the quarantine when the room temperature dropped to 10°C. Although it cannot be excluded that the health of the surviving animals was affected by this drop in temperature, these animals were still used in the test (I-H-116).

Response: The flow rate through the chambers varied from 900 to 1,900 liters/minute. The maximum number of animals in a chamber was 200 mice and 200 rats. This number of rats and mice will require an estimated 40 liters/minute. If the expired air contains about 5 percent CO_2, the CO_2 production will equal 2 liters per minute. Based upon the minimum air flow of 900 liters per minute in the chamber, the maximum CO_2 level should not exceed one-quarter of one percent. This is insignificant physiologically. Past experience has shown that if the animal cages are changed regularly and the chambers are washed daily, as was assumed to have been done under GLP procedures, ammonia buildup with three or more air exchanges per hour will be insignificant. Since the air flow through the chamber was 45 to 95 times the estimated expiratory minute volume of the entire animal population, and since the expired air itself is likely to contain only a few ppm of methane, it is unlikely that endogenously produced methane would influence the analysis of chamber vapor content to any detectable degree.

According to published results, temperatures in the four chambers ranged from 24 ± 1.4 to 26 ± 1.3°C and relative humidities from 52 ± 9.5 to 56 ± 7.2 percent. These are within the normal range for room temperature conditions.

Also, according to the published report, only animals that were apparently healthy were used. Since the animals were observed daily during the study for any detectable abnormalities, without any unusual findings in controls, it appears that the animals were normal. No mention of any animal deaths during the quarantine period was made in the published article.

Comment: One commenter noted that the lack of supporting weight of evidence from short-term bioassays (e.g., mutagenic responses), as well as other unexplained inconsistencies, may weaken the validity of the animal study results used for the health risk component of the cancer risk factor (I-H-126).

Response: While positive short-term bioassays would provide supportive evidence for carcinogenesis, the induction of tumors in two species, along with suggestive evidence from epidemiological studies, provides strong enough evidence to justify a quantitative estimate of risk.

Comment: One commenter pointed out that for gasoline vapors, EDB, and EDC, there is no definitive evidence of human cancer and the unit risk factor is based entirely on animal studies. The commenter suggested that attempting to quantitatively extrapolate animal data to humans is extremely risky (I-H-101).

Response: In this uncertain field, it is appropriate to make the conservative assumption that animal toxicology experiments are indicative of potential human health effects unless it can be shown that animal results are irrelevant, which is a difficult fact to establish.

The primary uncertainty in the use of animal data to assess cancer risk in humans is due to differences in sensitivity of the test species in comparison with humans. This could be due to differences in absorption efficiency, excretion rates, metabolic pathways, levels and inducibility of xenobiotic metabolizing enzmyes, DNA repair mechanisms, etc. The EPA/CAG is aware of these uncertainties and they are accounted for in the quantitative estimate of risk.

The compounds ethylene dibromide (EDB) and ethylene dichloride (EDC) are used as lead scavengers in additives to leaded gasoline. As leaded gasoline continues to become a smaller percentage of the gasoline sold in the U.S., emissions of these compounds are becoming negligible. Therefore, as discussed elsewhere in this document, although EDB and EDC have been shown to cause adverse health effects in experimental animals, these two substances are no longer being considered in this analysis.

Comment: One commenter noted the Agency's implicit assumption that the concentration at the location of the receptor is equal to the dose administered to the target organ (kidneys or liver) where the health impact will occur. The commenter did not think it was clear from the animal data whether this is the case for human exposure. The pharmacokinetics may not be the same for humans as it is for the test animals (I-H-126).

Response: While differences in pharmacokinetics may exist for many chemicals, such as cadmium compounds, the solubility of the compound appears to be a greater factor in concentration in the kidneys and liver than pharmacokinetic differences. Unless it can be shown that pharmacokinetic factors are responsible for a lesser susceptibility to gasoline vapors in humans than in animals, then any adjustment of the quantitative risk based on pharmacokinetics is not justified.

Comment: One commenter conceded that based upon historic data regarding spontaneous kidney carcinomas in rats, the incidence for the animals exposed in the API study must also be attributed to external influences. This statement must be qualified, however, by the fact that in this case of exposure, the tumors could only develop due to an endogenous nephropathy of the male rats (I-H-116).

Response: The male rat has been shown to be more susceptible to renal nephropathy from inhalation of gasoline than most other laboratory species tested. However, there is no direct evidence indicating that humans are less susceptible in this regard than male rats. Moreover, even if the general population is less susceptible, sensitive subgroups may exist. For example, Kazantzis, et al., 1962. Quart. J. Med. 31:403-419, reported data indicating the presence of a subpopulation of humans extremely sensitive to the nephrotoxic effects of mercury. This population resembled that of a genetically susceptible strain of rats in this respect.

The most significant evidence linking the development of renal tumors with renal nephropathy is a positive correlation between the two endpoints. While it is possible that tumorigenesis may be related to a promoting mechanism, such as continuous cell damage, it is also possible that the positive correlation may be completely fortuitous. In fact, several bits of evidence suggest that a tumorigenic response may not be dependent upon kidney pathology. First of all, mineralization of the renal pelvis was one of the common damaging effects of gasoline exposure in male rats, but there was no correlation between rats with mineralization and animals with kidney tumors. Secondly, two renal tumors were found in the kidneys of exposed female mice, a species which generally did not exhibit kidney pathology. Although the presence of only two tumors does not constitute a statistically significant increase, nevertheless, due to a low historic incidence the numbers are suggestive. Finally, a significant increase in liver tumors was detected in female mice, again with little accompanying liver pathology.

In summary, in order to discount the rat data it would be necessary to assume that male rats are both uniquely sensitive to gasoline induced renal nephropathy and that renal tumors arise as a result of the acute nephrotoxic phenomena being currently explored by API. Since neither hypothesis has been proven, the rat kidney cancer data are considered as indicating possible human carcinogenicity.

Comment: One commenter pointed out that in the API study some of the female mice contracted liver cancer and some of the male rats contracted kidney cancer, yielding two different cancer rates. The fact that the mouse data cannot even predict the rat data (or vice versa) reflects on the reliability of the numbers for humans (I-H-101).

Response: The rates of tumor induction in different strains, species, or target organs are seldom identical. The dose at the target organ, rates of activation or deactivation, DNA repair mechanisms, and many other factors will alter the response. This type of variability is inherent in any toxicology study, whether tumors or a nonocogenic response is the endpoint, and does not invalidate the results. In addition, the revised range of risk factors based upon rat data, which incorporate a data correction by API as presented to the SAB, encompasses the range of maximum likelihood to plausible upper limit estimates of risk based on mouse data.

Comment: One commenter did not understand why EPA used the results of only three of the available epidemiological studies in estimating risk and urged EPA to draw on all sound epidemiological studies, both negative and positive, in assessing potential hazards to human health (I-H-99).

Response: In the current analysis, 55 studies concerning exposure to gasoline vapors have been analyzed. Many of these studies did not prove to be relevant because of multiple exposures to compounds other than gasoline vapors.

9.2 RISK ASSESSMENT METHODOLOGY

9.2.1 General

Comment: One commenter felt that the health risk assessment methods were state-of-the-art and comprehensive. However, even though the approach was sound, the number of assumptions used in the analysis made it difficult to place a reasonable degree of confidence in the conclusions drawn in the report. (However, none of the assumptions appeared to be extremely unrealistic.) Also, they felt that since there appears to be some risk to persons in gasoline handling occupations, service station workers should have been included in the occupational group risk assessments (I-H-65). Two other commenters thought that risk estimates should be presented for all the employees at a service station (I-H-115, I-H-120).

Response: Since publication of the EPA analysis, the exposure assessment associated with benzene and gasoline vapors has been modified to now include occupational exposure of service station attendants. Shell Oil conducted personnel monitoring of service station attendants' exposure to gasoline vapors and benzene at seven service stations (I-F-13). Based on data presented in this study, a lifetime risk and base year incidence were estimated for these employees. The base year baseline occupational incidences were projected to other years by assuming that baseline incidence is proportional to total national gasoline throughput. The incidence reduction for occupational exposures was assumed to be 75 percent of the total percentage reduction calculated for a refueling strategy, since station attendants are exposed to sources of gas vapors and benzene other than refueling operations.

Comment: One commenter felt that the EPA analysis invariably made "worst-case" assumptions, thus maximizing estimates of potential risks and, in effect, factoring a hugely exaggerated safety margin into the results. This commenter saw little useful purpose in a calculation for an individual based on a worst-case unit risk factor multiplied by a worst-case exposure time (i.e., the case of a traveling salesman using 40 gal/week for 50 years). The end result is neither realistic nor objective (I-H-101).

Response: The EPA risk analysis is conservative in order to ensure that the public health and welfare are adequately protected in spite of uncertainty. However, the assumptions were not truly "worst-case" but are the middle to high end of the reasonably expected range. Thus, the resulting risk estimates may reflect relatively high exposure, but should be realistic and a proper basis for a prudent public health analysis. For example, in the case of lifetime risk, emission factors based on national average conditions (RVP and temperature) were used, while emission factors for the area with the most extreme conditions could be significantly higher.

Comment: One commenter suggested that the following factors should be resolved before a decision is made. Are the exposure estimates based on the most appropriate exposure models, modes of exposure, and calculation of exposed population? The methods used may be the best presently available, but are they grossly overestimating (or underestimating) the numbers of exposed population, concentration levels at the receptor, and the duration of exposure? The commenter asserted that these factors have a direct influence on the estimation of the cancer risk factor (I-H-126).

Response: The methodologies used in the original analysis were reassessed and determined to still be the best available for the purpose of reasonable estimates. The exposure models are the best available for such numerous and widespread sources. The modes of exposure considered both community exposure from dispersed emissions and individual exposure at service stations. The entire population of the country was considered at some exposure concentration in the various incidence analyses. The estimates in the risk analysis are of a reasonable magnitude. The assumptions and strategies were refined and revised as seemed warranted. For example, the unit risk factors, gasoline consumption, in-use efficiencies, and nonattainment coverages were revised. Also, additional exemption levels, onboard coverage (HDGV), and service station projections were reconsidered.

Comment: One commenter noted in particular that the benzene incidences are actually part of the gasoline vapor incidences, not an addition to them. The commenter stated that benzene is present only at refueling as a component of gasoline vapors, and should not be counted twice as EPA has done (I-H-101).

Response: The association between benzene exposure and leukemia has been well documented in several epidemiological studies. The benzene unit risk factor estimated from three occupational studies was used to calculate the benzene cancer incidence. The gasoline vapor unit risk factor was estimated from the API chronic inhalation study of unleaded gasoline vapors in rats and mice, and was used to calculate the gasoline vapor incidence. It is possible that some of the response to gasoline shown by the mice and rats is due to the benzene content. However, there is no conclusive evidence to support or deny that this response was due to the benzene component of gasoline. Further research is needed to identify which compounds or fractions of compounds are responsible for the carcinogenic effect. However, since the cancers caused by the gasoline vapors were tumors in the kidneys of rats and the livers of mice, rather than being leukemia (as would be expected from exposure to benzene only), the effects were assumed to be additive.

Comment: One commenter compared cumulative residual benzene incidence with onboard controls at 44 incidences over 35 years to Stage II control (with only 70 percent of self-service refuelings controlled) at 50 incidences. The commenter felt that this difference is probably not statistically significant, considering the many uncertainties involved (I-H-101).

Response: The revised analysis shows larger differences in the cumulative residual between incidences (as much as 85 for onboard vs. 106 for Stage II + Evap over 33 years). It is true that from a statistical viewpoint, confidence intervals of the two estimates may overlap. However, in light of limitations in knowledge and understanding, the estimates must be used as the best available basis for regulatory decisionmaking.

9.2.2 Exposure Measurements

Comment: One commenter noted that the EPA strategies evaluation report refers to "average" exposures being calculated from the exposure data for persons refueling their vehicles in an API study. However, the EPA report does not explain how this calculation was done (I-H-101).

Response: Data presented in the API/Clayton self-service refueling exposure study were used as the basis for calculating "average" exposures (I-D-17). During this study, samples were collected to characterize typical exposures to total hydrocarbons (measured as n-hexane), benzene, and eight other compounds at 13 service stations. API/Clayton calculated the geometric mean for each type of gasoline refueled (leaded, unleaded, and/or (unleaded) premium)) at each station. The geometric means of the mass concentrations reported by Clayton/API were used, along with the station temperature and the molecular weight of benzene or gasoline vapors, to derive a value of volume concentration in parts per million. An arithmetic mean volume concentration of benzene and gasoline vapors for each type of gasoline was calculated from these adjusted geometric means for each station.

9.2.3 Incidence

Comment: One commenter felt that EPA's assumption that the location of source sizes should be based on population densities (Section 4.1.2.1 of the July 1984 Analysis Report), and the estimate that bulk terminals have the highest emissions, would greatly overstate the exposed population and directly affect the calculated incidence. The commenter stated that bulk terminals are not usually located in the center of a high population-density area, and not all of the population in the vicinity of the facility would be equally exposed. Consequently, they felt that selecting the highest exposure level and applying it to the greatest number of people skews the cancer risk factor considerably. The commenter remarked that the bias may be somewhat modified by the terminal location method used. Exposure levels may be biased upward due to the assumption that the SHEAR version of the Human Exposure Model (HEM) is most appropriate. Use of a surrogate (benzene) to predict gasoline vapor concentration may be a source of error, but its use may provide a more accurate prediction of gasoline vapor concentrations. They also felt that use of the ISC dispersion model for the smaller gasoline vapor generators may modify the uncertainties associated with the HEM model. They considered this methodology to be the most conservative one to use for estimating exposure levels of a particular pollutant from a point source at the receptor locations (I-H-126).

Response: Bulk terminals and bulk plants could not be modeled on an individual basis since for both cases there are too many facilities nationwide (i.e., 1,500 bulk terminals, 15,000 bulk plants). A limited amount of data was available on the locations and throughputs of these types of facilities. In the case of bulk terminals, the model plant configurations, characteristics, and size distribution were taken from available data established during the development of the bulk terminal new source performance standards (NSPS) (I-A-34). Bulk plant model plant characteristics were based on previous EPA studies of this industry sector (I-A-9). The bulk terminal and bulk plant model plants were assumed to be distributed among locality sizes in which it was most likely that each size of model plant would be located. Based on industry data and experience, larger model plant sizes were generally assumed to be more likely to be located in more populated localities. Ten localities of varying sizes were chosen to represent the demographic and meteorological characteristics of all facilities within each model plant size range. The geographical distribution of localities representing each model plant size was as widespread as possible so that a cross-section of nationwide climatological conditions was also represented. The facility location method used did not locate bulk terminals or bulk plants within high population-density areas. On the contrary, most of the selected sites were in industrial areas or on the outskirts of a metropolitan area.

The SHEAR version of HEM is most appropriate when: (1) multiple pollutants from one source must be analyzed, (2) there are a large number of sources within an area that cannot be located individually, or (3) when the sources are so widespread that they act as an area source rather than several point sources. Thus, the SHEAR version was considered appropriate to model incidence from bulk terminals, bulk plants, and gasoline service stations. For bulk terminals and bulk plants, the point source routine of HEM was used. In this method, the population in the vicinity of the facility is not considered to be equally exposed. The HEM point source routine considers both the dispersion of pollutants around a source and the number of people residing (in the various census block groups) around the source in its calculation of the number of people exposed to various concentrations, and the resulting incidence. For service stations, the area source routine of HEM was used to calculate a single exposure concentration for the entire population of an area, assuming a uniform distribution of emissions.

The ISC model was used to estimate lifetime risk to an individual living around a complex of facilities, whether bulk terminals, bulk plants, or service stations. This model was used for lifetime risk because the contribution of each emission source to the ambient concentration at each receptor is calculated separately, considering the location and characteristics of each source. This level of detail was considered unwieldy and infeasible for the number of sources nationwide considered in the incidence analysis. This level of detail, however, was needed to assess the local scenario that was used to extrapolate to a nationwide analysis of the lifetime risk from high exposure.

Comment: One commenter felt that the total population exposure due to self-service refueling was erroneously obtained by dividing the annual self-service throughput by the average pumping rate. The commenter felt that the Agency's procedure is faulty because it does not define the size of the population exposed (I-H-127).

Response: The self-service vehicle refueling analysis assesses the risk to individuals other than station attendants from exposure to the high concentrations present near the tank fillneck during refueling. Thus, the computation of self-service incidence is based on the exposure incurred by one person during each self-service refueling. Since it is assumed that it will always be a single person pumping fuel, the total annual incidence is directly proportional to the annual self-service gasoline throughput. This relationship holds true because the total exposure time for all refueling is equal to the self-service throughput divided by the assumed average gasoline pumping rate of 8 gallons per minute.

Thus, the incidence can be calculated by taking the product of the exposure time for all self-service refuelings, the refueling concentration, and the number of people exposed per refueling (i.e., one). Under this approach, it can be seen that the impact of self-service refueling is independent of the size of the population exposed. In effect, while the entire self-service refueling population is considered, tenuous assumptions regarding the gasoline usage of specific individuals need not be made. Table 6-5 in the July 1984 Analysis Report outlines the calculation procedure used.

Comment: One commenter noted purported discrepancies in the July 1984 Analysis Report between EPA's stated method of risk analysis (Tables 6-5 and 6-8), the data base EPA states is used (Table 4-6), and the results presented (Table F-8). The commenter cited alleged errors, including: 1) inconsistencies in benzene levels used, 2) use of total gasoline consumption rather than only the self-service fraction, and 3) double counting of the population at risk (I-H-127).

Response: 1) For the self-service incidence analysis, average benzene exposure concentrations were calculated for both leaded and unleaded gasoline. In the case of unleaded gasoline, a weighted average benzene exposure for premium and regular unleaded gasoline was calculated. The average benzene exposures during self-service refueling were calculated to be 0.96 ppm for unleaded and 1.46 ppm for leaded. For the self-service incidence analysis, some consumers will be exposed to regular, and others to premium, unleaded gasoline. Thus, it was important to calculate a weighted average benzene exposure associated with the unleaded gasoline throughput, which was not differentiated between regular and premium. However, for the selfservice lifetime risk analysis, an average benzene exposure concentration for only regular unleaded gasoline was used, rather than a weighted average for both premium and regular (as in the self-service incidence analysis). This resulted in benzene concentrations of 0.98 ppm for unleaded gasoline and 1.46 ppm for leaded gasoline. The self-service lifetime risk analysis estimates the risk associated with high exposure to any one individual. Since leaded gasoline is being phased-out of the marketplace and was expected to be gone by the time frame of this analysis, the benzene concentration for regular unleaded gasoline was used in the lifetime risk analysis.

2) The EPA used the procedure outlined in Table 6-5 of the July 1984 analysis for the calculation of self-service incidence. (The procedure in Table 6-8 was used for self-service lifetime risk to an individual with high exposure.) This procedure does use only the self-service gasoline fraction. As suggested by the commenter, only the nonagricultural throughput was considered for service stations and the throughput already controlled by Stage II was considered. However, the existing Stage II throughput was calculated to be about 9 percent, rather than the 10 percent assumed by the commenter, and the associated incidence was calculated at controlled levels rather than zero.

3) The method used by EPA does not double count the population at risk. Although it may not have been clear in the abbreviated derivation given in Table 6-5, the projections of incidence in any given year were calculated using the ratio of leaded or unleaded throughput in the given year to the base year total national gasoline throughput. Thus, no correction is needed for the fraction of time each week spent pumping leaded or unleaded gasoline. In fact, the weekly pumping rates are assumed only for lifetime risk calculations, but are not used in the incidence calculations.

Comment: One commenter stated several alleged reasons for believing that the risk analysis underestimates the public health risks. The EPA has excluded passengers in cars at service stations who are exposed during refueling. Furthermore, even though OSHA has the authority to protect employees, it is indefensible that the analysis ignore the cancer incidences associated with employees and the resulting employee incidence reduction resulting from the control strategies (I-H-115).

Response: The EPA considered the inclusion of passengers in cars at service stations during refueling. However, the exposure concentration is proportional to the inverse of the cube of the distance from the source; windows are closed about one-half of the year, even on cars without air conditioning; and the fraction of cars with air conditioning and, thus, with windows closed nearly year-round is increasing. Therefore, the incidence due to passenger exposure was considered in the analysis to be negligible. For lifetime risk due to high exposure, a high estimate of passenger exposure was considered in developing the assumption of 50 years of equivalent 40 gal/week usage. Even so, the passenger exposure contribution to total lifetime risk was nearly negligible. Although OSHA has the authority to protect employees, estimates of the incidence resulting from occupational exposure of service station employees were included in the reanalysis. The inclusion of service station occupational incidence provides a more complete assessment of the baseline incidence due to vehicle refueling and the benefits of the various control strategies.

9.2.4 Lifetime Risk

Comment: One commenter stated that EPA declined to sum the category-by-category lifetime risk on the assumption that it is unlikely that any one individual would be exposed to high exposures from any two source categories. The commenter claimed that this assumption is flawed because it is highly probable that some of the most exposed persons near various types of wholesale operations also frequently visit, or may even work at, service stations (I-H-115).

Response: The EPA still deems it appropriate to calculate the lifetime risks by individual source category and consider them separately. In particular, the individual categories are controlled by different control options, so presenting the individual categories presents the resulting risk reductions more clearly. Admittedly, some individuals may be exposed to several source categories at the same time. However, it is less likely that they would be subject to high exposures from all categories, because the high exposure scenarios assume that several of one type of facility are close together. To examine the possible impacts, the lifetime risks could be added together, but the resulting sums would not differ significantly from the risk for bulk terminals alone.

9.3 EXPOSURES DURING SELF-SERVICE REFUELING*

9.3.1 Gasoline Pumping Rate*

Comment: Two commenters felt that EPA's use of 8 gal/min to represent the range of pumping rates of 8 to 12 gal/min inflates the apparent risk from self-service (I-H-114, I-H-127). Another commenter also disagreed with the EPA assumption that gasoline pumps operate at an average of 8 gal/min. The EPA had justified this value on the basis that filling rates are frequently extended by persons "topping off", or by automatically reduced pumping rates at the end of prepaid fill-ups. Although the commenter agreed that this does increase exposure time, it seems that gasoline vapor concentrations would be proportionally reduced due to a slower pumping rate. The end result of EPA's assumption is a 50 percent higher prediction of cancer among people who fuel their own vehicles (I-H-101).

Response: Data received from API (I-D-38) and other background data on gasoline pumping rates were re-examined. These data showed that gasoline pumps typically operate within a range of 6.5 to 12 gallons per minute. The API stated that roughly one-half of the service station pumping systems use suction pumps, which normally can operate at 8-9 gpm, while the other half use submersible pumps, which typically can operate at 10 gpm or more, but vary in rate depending upon the number of nozzles operating simultaneously and the pumping distance. The API also stated that some cars must be filled at low rates to avoid nuisance shutoff, and reported the statement of one nozzle manufacturer's engineer that the average automobile fill configuration would not accept more than about 8 gpm without nuisance shutoff. The Agency concluded that the 8 gallon per minute level was a reasonable assumption. A Stage II system may generally require a slower pumping rate than an onboard system; however, this could not be clearly determined from the data. The API reported, for example, that "second-generation" balance systems operate at 5-8 gpm, while newly certified systems allow 10 gpm.

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*1984 Federal Register Topic.

9.3.2 Number of Tank Fillings*

Comment: One commenter cited recent studies showing average annual miles traveled per household vehicle as ranging between 10,100 and 11,600. Average fuel efficiency of household vehicles was given as 14.7 mpg in 1982, and projections of average fleet fuel economy of 17.5 mpg in 1984, 23.8 mpg in 1990, and 27.9 mpg in 1995 were reported. Assuming that the average vehicle miles traveled (VMT) in the 1995 to 2000 time period will be 11,000 miles per year at a fuel efficiency of 27.9 mpg, the commenter calculated the average fuel consumption per vehicle as 394 gal/yr. Assuming a weekly fill, this would be equivalent to a consumption of approximately 7.5 gal/week. If a high exposure is represented by a salesperson traveling 3 to 5 times the average VMT, the fuel consumed would range between 23 and 38 gal/week, so that the EPA assumption of 40 gal/week seems very high. Furthermore, they noted that the assumed high exposure period of 50 years of life implies that such people would be driving the same number of miles, even when 70 years old (assuming the average salesperson begins employment at age 20). Since most people retire at around 65 years of age, they thought that driving 3 to 5 times the average VMT for 50 working years overstates the exposure risk. The commenter suggested that an estimate of 30 to 35 working years and an average use of about 30 gal/week may be more reasonable for the high exposure scenario (I-H-126).

Response: As the commenter estimated, 38, or about the 40 gal/week used in the analysis, is a high, but reasonable, usage rate for a high exposure scenario. Although a correspondingly high working life might be 45 years (from 20 to 65 years of age), the 50-year exposure life was assumed in order to account for lower usage rates before employment and after retirement. The 30 to 35 working years and average use of about 30 gal/week suggested by the commenter are, indeed, reasonable estimates of average usage or high typical usage. The EPA estimate, however, although not a maximum exposure scenario, is designed to reflect the high end of exposures that could reasonably be expected.

9.3.3 Exposure Concentrations*

Comment: One commenter stated that his company had collected 14 air samples to measure face level customer exposure to benzene and other hydrocarbons during self-service filling, and found the average total hydrocarbon concentration to be similar to that used in the EPA evaluation. However, benzene concentrations were measured at 0.04 to 0.15 ppm, and averaged 0.06 ppm (compared to EPA's figures of 0.96 ppm for unleaded and 1.46 ppm for leaded gasoline) (I-H-24).

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*1984 Federal Register Topic.

Two other commenters stated that the API/Clayton self-service exposure concentrations are most likely unrepresentative in terms of both population distribution and seasonal variation. In addition, these commenters felt that the concentrations were questionable because the benzene-to-gasoline vapor ratio seemed too low and because the benzene vapor content was found to be higher for leaded gasoline than for unleaded gasoline (I-H-114, I-H-127). One of the commenters concluded that the results of the API/Clayton study are not relevant for determining health effects from refueling vapors (I-H-127). The commenters further concluded that the uncertainties cast doubt on whether self-service is dominant in nationwide risk.

One commenter requested further information about the methodology used in the API exposure study, stating that ambient and tank temperatures, wind speed and direction, humidity, position of sampler, fill rate, and sampling pump flow rate can all affect air concentration measurements (I-H-72). Another said that there is some question as to the validity of the API/Clayton exposure data, with regard to the sample flow rates used, the statistical manipulation of data, and the high benzene concentrations found in the gasoline bulk samples (I-D-51).

One commenter stated that the variability in the actual measured exposure data could not be determined from the evaluation document, remarking that use of the maximum observed vapor concentration may overstate the exposure, while average observed concentrations may understate the same exposure (I-H-126).

Response: The Clayton work is, in EPA's assessment, the most comprehensive refueling study available. In addition, the results of the Clayton study are basically similar to the results of other studies. It is true that the mean results of studies assessing time-weighted averages (TWA) of service station employees vary from 0.08 to 0.55 ppm for benzene, with a total range of individual measurements of <0.01 to

2.08 ppm (I-F-13, I-D-17). The only study assessing total gasoline vapors reported a mean of 8.3 ppm and a range of 0.42 to 114 ppm (I-F-13). These results for time-weighted averages of occupational exposure are in general agreement with those reported by the commenter (I-H-24).

The Clayton study, however, assessed exposure concentrations during refueling time only, which is the relevant concentration for self-service refueling. A statistical analysis was performed of the station geometric means of concentrations by volume, calculated from the Clayton concentrations by mass and station temperatures. The results are as follows:

Pollutant/ Gasoline Type	Arithmetic Mean	Number of Stations	Minimum	Maximum	Lower 95% Confidence Limit	Upper 95% Confidence Limit
BENZENE						
Unleaded Regular	0.98	13	0.41	1.79	0.70	1.26
Leaded Regular	1.40	12	0.54	4.11	0.78	2.02
Premium Unleaded	0.82	8	0.10	1.61	0.32	1.32
All Unleaded (Ann. Avg.)	0.96	NA	0.38	1.77	0.65	1.26
All Gasoline (Ann. Avg.)	1.03	NA	0.40	2.15	0.67	1.39
GASOLINE VAPORS						
Unleaded Regular	61.1	13	19.1	126	41.8	80.4
Leaded Regular	76.2	12	18.0	174	43.0	109.4
Premium Unleaded	69.2	9	25.4	150	40.9	97.6
All Unleaded (Ann. Avg.)	62.0	NA	19.8	129	41.6	82.4
All Gasoline (Ann. Avg.)	64.3	NA	19.5	136	41.9	86.8

As can be seen, the annual average values for benzene from all gasoline is 1.0 ppm with 95 percent confidence limits of 0.67 and 1.39 ppm. The range of station geometric means was 0.40 to 2.15 ppm weighted for all gasoline types, or 0.10 to 4.11 ppm for the most extreme values for any fuel type. Other studies reported values for refueling time only with means of 0.1 to 1.2 ppm and a total range of <0.01 to 3.2 ppm (I-F-13, I-F-141). As shown above, the Clayton-based annual average values for gasoline vapors from all gasoline is 64.3 ppm with 95 percent confidence limits of 42 and 82 ppm. The range of station geometric means was 20 to 136 ppm weighted for all gasoline types, or 18 to 174 ppm for the most extreme values for any fuel type. The one other available study reported values for refueling time only with a mean of 41.7 ppm and a range of 1.8 to 99 ppm.

The EPA's Environmental Monitoring Systems Lab (EMSL) also conducted a brief refueling exposure study (I-A-67). The results of this study agreed well with the data used as a basis for the risk analysis.

9.4 REFERENCES (Comment letters are not repeated here. See Chapter 1, Table 1-1, for a complete list of comment letters.)

I-A-9 Study of Gasoline Vapor Emission Controls at Small Bulk Plants. U.S. EPA, Region VIII. Prepared by Pacific Environmental Services, Inc. October 1976.

I-A-34 Bulk Gasoline Terminals - Background Information for Proposed Standards. U.S. EPA. Research Triangle Park, NC. EPA-450/3-80-038a. December 1980.

I-A-67 Self-Service Station Vehicle Refueling Exposure Study. Environmental Monitoring Systems Laboratory, U.S. EPA. Research Triangle Park, NC. Undated.

I-D-17 Letter and enclosure from O'Keefe, W.F., American Petroleum Institute, to Newbury-Rin, S., U.S. EPA, Office of Toxic Substances. September 20, 1983. Transmittal of final report: "Gasoline Exposure Study for the American Petroleum Institute (API), Washington, D.C.," prepared by Clayton Environmental Consultants, Inc., dated August 25, 1983.

I-D-38 Letter and enclosures from Crockett, P.E., American Petroleum Institute, to Gray, C.L., U.S. EPA. August 8, 1984. Information on gasoline dispensing rates.

I-F-13 Quest for a Gasoline TLV. McDermott, H.J., et al., Shell Oil Company, San Ramon, California. American Industrial Hygiene Association Journal (39):110-117. February 1978.

I-F-103 Health Effects of Benzene. Part B. State of California Department of Health Services/Epidemiological Studies Section. July 1984.

I-F-141 "Service Station Attendant's Exposure to Benzene and Gasoline Vapors." American Industrial Hygiene Association Journal (40): 315-321. April 1979. H.J. McDermott and G.A. Vos, Shell Oil Company, San Ramon, California.

10.0 OTHER METHODOLOGIES AND CONSIDERATIONS

10.1 LEGAL AND POLICY CONSIDERATIONS

Comment: One commenter felt that EPA should adopt Stage I controls for all sources that currently do not have these controls (including bulk plants, terminals, and service stations). Further, the Agency should require achievement of the lowest achievable emission level, rather than RACT limits, which are considerably higher than the limits that can be reached with the same technology using good operational and maintenance practices. An example of this difference was provided by the commenter for bulk terminals, where the RACT limit for vapor processors is 80 mg/liter, and the LAER limit is 30 mg/liter (I-H-115).

Response: The Agency is currently considering the role of Stage I controls in the gasoline marketing regulatory program. No final decisions have been reached on the application and stringency of such controls.

Comment: One commenter felt that the comprehensiveness of EPA's July 1984 analysis makes for an unwieldy document in which important issues are lost in trivia. For example, since Stage I was shown to have a negligible effect on annual incidences of cancer and all ozone nonattainment areas should have adopted Stage I, they felt there was little sense in carrying on with the analysis of Stage I on a nationwide basis (I-H-21).

Response: The Agency considers it important to include an evaluation of Stage I impacts because Stage I is part of the gasoline marketing chain. Moreover, Stage I annual incidence estimates in the analysis provide a basis for comparison of the relative impacts of the several exposure pathways and sources.

Comment: One commenter felt that attention should be given to the strategies that will meet established needs, such as: nationwide Stage I control to remove more than half of the gasoline vapors at low cost, Stage II control in areas that must attain ozone air quality standards by the 1987 deadline, and reduction of the vapor pressure of gasoline to restore current evaporative controls to a better working order (I-H-101).

Response: The question of whether to require adoption of Stage I controls beyond nonattainment areas, where it is already required, is still being considered by the Agency. The rulemaking actions taken by the Agency include a proposal to reduce in-use fuel volatility, as the commenter suggests. As described in the proposal for onboard control of vehicle refueling, the Agency currently does not intend to require Stage II controls in areas where it is not presently installed (or being installed) or where the applicable SIP does not contain a commitment to install Stage II. However, it is a potential measure for States to consider in developing revised nonattainment plans (see the onboard Federal Register announcement for further discussion of Stage II issues).

Comment: One commenter felt that the July 1984 EPA analysis represents an important departure from custom at EPA, in that health effects and control alternatives are analyzed simultaneously. In the past, they noted that EPA has established that there is a problem and then independently endeavored to solve it. They felt the evaluation establishes that there are essentially two problems, i.e., ozone nonattainment and cancer incidences, that may not have the same solution. They felt the effort to simultaneously analyze health effects and control alternatives fails to assign a monetary value to reductions in morbidity or mortality associated with the control strategies. Furthermore, they noted that the precedent is hereby established for the selection of control alternatives based on "dollars per cancer incidence prevented." They felt Congress clearly did not intend such compromises when it promulgated the Clean Air Act (I-H-21).

Response: The EPA does not agree with the commenter's view that it is Agency policy to ignore potential solutions when analyzing environmental problems. The Agency assesses possible courses of action in its analytical work; to do otherwise would be irresponsible. The gasoline marketing analysis on which comment was sought presented the regulatory alternatives in some detail for the express purpose of stimulating comment from the public. Concerning the nature of the problem, the commenter suggests that there are two aspects--ozone nonattainment and hazardous exposure. In fact, there are more, including transport of ozone and ozone precursors from attainment to nonattainment areas, maintenance of air quality in ozone attainment areas, and potential benefits derived from reducing ozone levels in attainment areas. As explained in the Federal Register proposal, EPA believes that vehicle onboard controls is the solution that, overall, deals best with all of these problems.

It is true that a specific monetary value for reduction in morbidity was not included in the analysis (except for the implied benefit for reducing VOC in nonattainment areas, which is primarily concerned with morbidity effects). The ability to monetize morbidity effects (as related to levels of exposure) for pollutants such as benzene and gas vapors is limited, because such linkages are not well defined. To the extent that such effects (and benefits) exist, the analysis understates the advantages of controlling refueling emissions.

Comment: Several commenters questioned the interpretation of Sections 112 and 324 of the Clean Air Act applied in the analysis. Two commenters examined Sections 112 and 324 and the relevant legislative history, and believe it is clear that Congress intended to allow the control of a hazardous air pollutant to take precedence over the exemption for "independent small gasoline marketers" (I-H-114, I-H-127). Another commenter felt the legislative history and a legal construction of Sections 324 and 112 indicate that Section 324 applies to any regulations or statutory authority that require the installation of vapor recovery equipment. Therefore, a reasonable interpretation would conclude that the exemption of small marketers allowed in Section 324 is appropriate with regard to any refueling strategies mandated under Section 112 (I-H-102). One commenter pointed out that neither Section 324 of the Act nor anything in its legislative history affirmatively requires EPA to regulate nonindependent stations below 50,000 gallons per month and that Congress was not trying to give independent stations a competitive advantage, but was seeking to protect them from economically infeasible capital expenditures (I-H-94).

Response: Section 112 of the Act authorizes the Administrator to set emission standards for hazardous air pollutants. The strategies evaluation was conducted, in part, to examine the feasibility of setting Section 112 standards requiring vapor recovery on gasoline refueling operations.

Sections 323 and 324 provide:

> §323 . . . (a) The regulations under this chapter applicable to vapor recovery with respect to mobile source fuels at retail outlets of such fuels shall provide that the cost of procurement and installation of such vapor recovery shall be borne by the owner of such outlet .... .
>
> §324 . . . (a) The regulations under this chapter applicable to vapor recovery from fueling of motor vehicles at retail outlets of gasoline shall not apply to any outlet owned by an independent small business marketer of gasoline having monthly sales of less than 50,000 gallons ... .
>
> (b) Nothing in subjection (a) shall be construed to prohibit any State from adopting or enforcing, with respect to independent small business marketers of gasoline having monthly sales of less than 50,000 gallons, any vapor recovery requirements for mobile source fuels at rental outlets. . . . Any vapor recovery requirement which is adopted by a State and submitted to the Administrator as part of its implementation plan may be approved and enforced by the Administrator as part of the applicable implementation plan for that State ... .

The Conference Report on these provisions states:

> Under the conference agreement, no station which is owned by an independent marketer and which has monthly throughput of less than 50,000 gallons of gasoline may be required, directly or indirectly, by the Administrator under this Act to install and use vapor recovery equipment.

H.R. Rep. No. 564, 95th Cong., 1st Sess. 182 (1977).

The House Report explains the origin of the provisions:

> This approach [vapor recovery] is regarded as a necessary, but not sufficient, strategy in many areas for attaining the national primary oxidant standard.
>
> * * * *
>
> However, one major problem has become evident in the implementation of these [vapor recovery] controls. That problem[ ] is the capital costs of control which currently must be borne by the owner or operator of the station.

H.R. Rep. No. 294, 95th Cong., 1st Sess. 299 (1977). Rep. Whalen had introduced Section 324 as a floor amendment with these words:

> It would be a serious blow to our economy if the price we had to pay for applying the Stage II [vapor recovery] regulations to independent marketers were the loss of, or serious damage to, the independent segment of the gasoline marketing industry.

Congressional Research Service, A Legislative History of the Clean Air Act Amendments of 1977 at 6483 (1978).

Absent persuasive reasons to the contrary, statutes are interpreted according to their plain meaning. E.g., CPSC v. GTE Sylvania, 447 U.S. 102 (1980). Sections 323 and 324 on their face apply to any regulations under the Clean Air Act including standards promulgated under Section 112. Their broad application is also supported by the legislative history; the Conference Report states that they forbid that small gas stations "... be required directly or indirectly, by the Administrator under this Act to install and use vapor recovery equipment." (emphasis added).

It is true that Congress did not specifically address the application of Sections 323 and 324 to Section 112 standards, but "the absence of congressional focus is immaterial where the plain language applies." Jefferson City Pharmaceutical Ass'n v. Abbot Laboratories, 460 U.S. 150, 103 S.Ct. 1011, 1017 n. 18 (1983). "[I]t is no bar to interpreting a statute as applicable that the question which is raised on the statute never occurred to the legislature." Eastern Air Lines, Inc. v. C.A.B., 354 F.2d 507, 511 (D.C. Cir. 1965), citing Cardozo, The Nature of the Judicial Process, 15 (1921). Accord, Montana Power Co. v. F.P.C., 445 F.2d 739, 746 (D.C. Cir. 1970), cert den. 400 U.S. 1013 (1971); Portland Cement Ass'n v. Ruckelshaus, 486 F.2d 375, 380 (D.C. Cir. 1973), cert. den. 417 U.S. 921 (1974).

Moreover, statutes should be interpreted consistent with Congress' intent. E.g., U.S. v. Braverman, 373 U.S. 405 (1963). Congress' clear intent in Sections 323 and 324 was to relieve at least some gasoline retailers of certain economic burdens which might be imposed by EPA regulations. Construing these sections to apply to Section 112 standards is consistent with that intent.

Comment: One commenter expressed concern over the omission in the EPA report of the statement by Vice President Bush in April 1981, that onboard control of refueling emissions would not be imposed on the automotive industry (I-H-117).

Response: The Vice-President's statement of April 1981 and EPA's own public announcement of its decision (I-G-7), were made at a time period when the domestic automobile manufacturing industry was experiencing massive layoffs and corporate losses. Since that time, the economic health of this industry has improved considerably. In light of that and more relevant information on the potential need for refueling controls, the Agency believed that an up-to-date evaluation of the potential impacts and desirability of onboard controls was warranted.

Comment: One commenter stated that EPA has a legal requirement to make three decisions concerning emissions of hydrocarbons in vehicle refueling: (1) Is regulation needed for direct protection of public health? (2) Is regulation necessary and cost effective for the reduction of atmospheric oxidants in nonattainment areas? and (3) If regulation for either reason is needed, should it be accomplished by control onboard the vehicle or at service stations (I-H-99)? This commenter also stated that EPA must decide whether vehicles in-use are complying adequately with the evaporative emission standard and, if not, how best to assure the adequate compliance of these and future vehicles. Furthermore, this commenter stated that it is essential that the option chosen be one that will achieve the desired result at a minimum cost to the motoring public and, thus, EPA must avoid redundant actions. Specifically, the commenter felt EPA must avoid requiring both onboard and service station controls, both RVP restrictions and service station controls, or both RVP restrictions and onboard controls. For the public good, EPA must identify the one most cost-effective control option (I-H-99).

Response: The Agency clearly is not limited to identifying "the one most cost-effective control option." Based on an extensive analysis of a broad range of options, the Agency has proposed to regulate refueling emissions with onboard controls and to limit the volatility of in-use motor fuel. The rationale for these actions is thoroughly explained in the rulemaking proposals and accompanying support documents.

Comment: One commenter felt that the Clean Air Act does not permit EPA to reject available measures for controlling carcinogenic pollutants on the basis of cost considerations (I-H-115).

Response: Neither Section 112 nor its legislative history states that costs may not be considered. On the contrary, the legislative history indicates that cost factors may be taken into account. Section 112 was enacted in 1970. All of the bills considered by Congress provided that EPA could consider feasibility in setting standards for hazardous air pollutants. For example, the Senate Report notes:

> The committee recognizes that some of these hazardous pollutants . . . are present in nearly all raw materials ... . Recognizing that complete control . . . may not be . . . practicable, the Committee has provided the Secretary with authority to differentiate among categories ... .

S. Rep. No. 1196, 91st Cong., 2d Sess. 20 (1970), reprinted in Congressional Research Service, A Legislative History of the Clean Air Act Amendments of 1970 at 420.

There are sound reasons for interpreting Section 112 as permitting consideration of cost and feasibility when carcinogens are concerned. As EPA has consistently observed in Section 112 rulemakings, there is no direct evidence that air pollutants cause cancer. That is, there are no studies showing an increased incidence of cancer in humans due to exposure to particular pollutants in the ambient air. Instead, regulation of airborne carcinogens is based on studies of workers exposed in the workplace and animals exposed in laboratory experiments. However, the workplace and laboratory exposures are much higher, generally many orders of magnitude higher, than the levels of these carcinogens found in the ambient air. It is only by extrapolation from the higher exposures to ambient levels that the Agency concludes that the air pollution due to these carcinogens threatens public health within the meaning of Section 112. This extrapolation is based on the "no threshold" assumption, i.e., that any exposure to a carcinogen presents some risk, although the risk becomes vanishingly small as the exposure does. Under the no threshold assumption, emission standards for carcinogens under Section 112 could prevent all risks only by preventing all emissions and, hence, all exposures.

But EPA does not believe that Congress intended Section 112 standards to prevent all risks. Section 112(b)(1)(B) simply requires that standards be "at the level which in [EPA's] judgment provides an ample margin of safety to protect the public health from such a hazardous air pollutant." First, the requirement for an ample margin of "safety" does not imply eliminating all risk. For example, the Occupational Safety and Health Act requires standards that "provide safe or healthful employment and places of employment." As the Supreme Court held in reviewing an OSHA benzene standard, " . . . safe is not the equivalent of 'risk-free.'" Industrial Union Dept., AFL-CIO v. American Petroleum Institute, 448 U.S. 607, 642 (1980).

Second, Congress did not contemplate that Section 112 would require the elimination of all risk from, and all emissions of, carcinogens. Virtually every basic industry in our society - chemicals, petroleum, electric power, metals - emits one or more of the six carcinogens listed under Section 112 (asbestos, vinyl chloride, benzene, inorganic arsenic, radionuclides, and coke oven emissions). In most cases, these emissions cannot be completely eliminated. Therefore, standards prohibiting all emissions (and eliminating all risk) would effectively shut down the Nation's basic industry. The legislative history of Section 112 makes clear that Congress had no such draconian results in mind. See Proposed Policy for Airborne Carcinogens, 44 Fed. Reg. 58642, 58659 - 58661 (October 10, 1979).

In these circumstances, EPA has established Section 112 standards for carcinogens at levels that reflect demonstrated, effective control systems. This reduces, but does not eliminate, emissions, exposure, and risk. It necessarily involves considering feasibility and cost. First, a control system cannot be considered demonstrated or effective unless it is feasible. Second, whether a system is feasible depends in part on the reasonableness of its cost.

The EPA has consistently interpreted Section 112 to permit the Agency to consider cost and feasibility, at least when setting standards for carcinogens. The EPA began implementing Section 112 on March 31, 1971 (only 3 months after its enactment), when it listed 3 hazardous air pollutants, including the carcinogen asbestos. 36 Fed. Reg. 5931. The EPA thereupon proposed asbestos emission standards which, in every case, were based on identified and feasible control techniques. 36 Fed. Reg. 23239 (December 7, 1971). In promulgating those rules EPA stated that:

> The EPA considered the possibility of banning production, processing, and use of asbestos or banning all emissions for asbestos into the atmosphere, but rejected these approaches ... . Either approach would result in the prohibition of many activities which are extremely important ... . For example, demolition of any building containing asbestos fire proofing or insulating materials would have to be prohibited . . . 38 Fed. Reg. 8820 (col. 2) (April 6, 1973).

The EPA has continued consistently to base Section 112 standards for carcinogens on consideration of, among other things, cost and feasibility. Amendments to standards for asbestos, 39 Fed. Reg. 38064 (October 25, 1974); 40 Fed. Reg. 48229 (October 14, 1975); standards for vinyl chloride, 40 Fed. Reg. 59532 (December 24, 1975); 41 Fed. Reg. 46560 (October 21, 1976); proposed amendments to standards for vinyl chloride, 42 Fed. Reg. 29005 (June 7, 1977); amendments to standards for asbestos, 43 Fed. Reg. 26372 (June 19, 1978); standards for benzene, 46 Fed. Reg. 1165 (January 5, 1981); 49 Fed. Reg. 23498 (June 6, 1984); proposed standards for benzene, 45 Fed. Reg. 26660 (April 18, 1980); 45 Fed. Reg. 83448 (December 18, 1980); 45 Fed. Reg. 83952 (December 19, 1980); standards for radionuclides, 48 Fed. Reg. 15076 (April 6, 1983); 49 Fed. Reg. 43906 (October 31, 1984); standards for inorganic arsenic, 51 Fed. Reg. 27956 (August 4, 1986)

This consistent and long-standing view of the Agency charged with implementing Section 112 is entitled to substantial deference. E.I. du Pont de Nemours & Co. v. Collins. 432 U.S. 46, 54-55 (1977). See Chevron USA, Inc. v. NRDC, 467 U.S. 837 (1984).

Moreover, when Congress re-enacted the Act in 1977, it was well aware of EPA's settled interpretation of Section 112. By that time, the standards for asbestos and vinyl chloride had been proposed, promulgated, and litigated. Indeed, the principal amendment to Section 112 was the explicit authorization of design, equipment, work practice, and operational standards (Section 112(e)), which were the heart of the asbestos standards. The legislative history states that "[t]his limited provision would fully authorize the present EPA regulations governing asbestos." S. Rep. No. 127, 95th Cong., 1st Sess. 44 (1977), (enacted Amendments adopted the Senate bill without significant change, See

H.R. Rep. No. 564, 95th Cong., 1st Sess. 131-132 (1977) (Conference Report)). Congress' re-enactment of Section 112 with full knowledge of EPA's interpretation further shows that interpretation to be reasonable. North Haven Board of Education v. Bell, 456 U.S. 512, 102 S. Ct. 1912, 1925 (1982); NLRB v. Bell Aerospace Co., 416 U.S. 267, 274-275 (1974), and cases cited therein.

The EPA disagrees with the commenter's claim that there is a general legal principle forbidding consideration of cost under any statute using the phrase "margin of safety." For example, in National Ass'n of Demolition Contractors (NADC) v. Costle, 565 F.2d 748 (D.C. Cir. 1977), the Court upheld EPA's action in setting asbestos standards based on feasible control systems:

> NADC argues that the Administrator's statutory mandate to protect the public health with "an ample margin of safety" is inconsistent with his decision to use the "best available control methods .... We disagree.
>
> Protection of the public with "an ample margin of safety" may necessitate use of different control measures .... 565 Fed. Reg. F.2d at 753.

The cases cited by the commenter, Lead Industries Ass'n v. EPA, 647 F.2d 1130 (D.C. Cir. 1980), cert. den. 449 U.S. 1042 (1980); American Petroleum Institute v. Costle, 665 F.2d 1176 (D.C. Cir. 1981), cert. den. 102 S.Ct. 1737 (1982); Hercules, Inc. v. EPA, 598 F.2d 91 (D.C. Cir. 1978), interpret only two statutory provisions, Section 109 of the Clean Air Act, and Section 307 of the Clean Water Act. Those cases do not set forth a general principle that a statute using the phrase "margin of safety" forbids consideration of feasibility and cost. On the contrary, those cases were based on detailed examination of Sections 109 and 307, each taken as a whole, along with their legislative history, Agency interpretation, and the facts involved. In all these respects, the cases are entirely different from the regulation of carcinogens under Section 112.

Comment: Three commenters believed Section 202(a)(6) of the Clean Air Act requires EPA to perform an analysis of Stage II and onboard, and the Agency must issue onboard regulations if they are desirable and feasible. The analysis indicates that onboard is superior to Stage II;

therefore, EPA must issue onboard regulations if it is to comply with the statutory directive (I-D-54, I-H-108, I-H-119). A second commenter also believed that the application of Section 202(a)(6) to the findings contained in the Strategies Document effectively prohibits the selection of Stage II vapor recovery as a control strategy (I-H-102). Another commenter pointed out that Section 202(a)(6) of the Act requires that onboard be studied as a substitute for gasoline vapor recovery (Stage II), and not as a complement to it. Thus, EPA's analysis appears to be contrary to the intent of Congress. The commenter concluded that no such legal questions would impede the expeditious implementation of a Stage II program (I-H-93). One commenter pointed out that in enacting the Clean Air Act Amendments of 1977, Congress recognized the potential advantages of onboard controls in Section 202(a)(6), which requires EPA to prescribe onboard controls in preference to Stage II vapor recovery if the EPA Administrator finds employment of onboard controls to be feasible and desirable (I-H-94). One commenter stated that, if onboard controls are found to be the preferred strategy, the Agency should mandate these controls under Section 202(a) to "lock in" their long-term benefits (I-H-94).

Response: The EPA agrees that Section 202(a)(6) requires promulgation of onboard controls if they are ultimately determined by EPA to be "feasible and desirable." As fully discussed in the proposed onboard rulemaking, EPA believes, at this time, that onboard controls are "feasible and desirable" and has proposed such controls. Of course, EPA welcomes comments on its current belief as to both the feasibility and desirability issues. If EPA finally concludes that they are feasible and desirable, onboard controls will be required.

As to the second commenter, EPA is not sure of the exact meaning of the somewhat vague suggestion that the "findings" in the Strategies Document (July 1984 analysis) preclude selection of Stage II controls. However, as discussed in the proposed onboard rule, EPA is proposing not to require Stage II controls as a reasonably available control strategy for all ozone nonattainment areas under Section 172 of the Act.

Regarding the comment that Section 202(a)(6) allows onboard only as a "substitute" and not as a "complement" to Stage II, EPA does not necessarily agree with the commenter's conclusions. Although Section

202(a)(6) requires EPA to determine the "feasibility and desirability" of onboard controls which would avoid the necessity of Stage II, it does not expressly preclude EPA from requiring both onboard and Stage II, if appropriate, after making such a determination. In any event, as discussed in the onboard proposal, EPA currently believes onboard is an effective substitute for Stage II and proposes not to require Stage II for all ozone nonattainment areas under Section 172 of the Act. (This response also applies to the third commenter discussed above.) Of course, as stated in the onboard proposal, EPA expects States which have installed (or are installing) Stage II to continue to implement that measure unless and until they are replaced by onboard controls, and those States which have SIP commitments to install Stage II to do so unless and until adequate substitute measures are submitted and approved.

As to the final comment discussed above, EPA has proposed to require onboard controls and will promulgate such controls -- thus "locking in" their benefits -- if, after evaluating the public comments on the proposal, EPA finally determines that they are feasible and desirable.

10.2 SUGGESTED REGULATORY APPROACHES

Comment: One commenter felt that there is no reason to require Stage II in areas now attaining the ozone ambient standard. Implementation of Stage II systems in nonattainment areas would require that EPA take three main actions: (1) set a VOC recovery (emission reduction) standard, (2) develop a procedure for certifying compliance with the standard, and (3) define an implementation schedule.

This commenter suggested an emission standard no lower than 0.4 gram per gallon of gasoline dispensed under average conditions. A certification test, developed in conjunction with outside technical consultation, should be required only on a prototype system, and not at every service station utilizing the system. With regard to the schedule for implementation, the commenter felt all marketers should be required to meet the same installation schedule. Further, exemptions given to small or independent marketers would often be unjustified because many small facilities (non-retail trucking, automotive, or government) are financially able to afford controls, and a facility's emissions contribution does not depend on whether it is run by a major or an independent marketer. The commenter expressed strong opposition to exemptions based on company affiliation (I-H-99).

Response: As explained in the proposed rulemaking, EPA does not intend to require adoption of Stage II in areas where it is not now in place or being installed or contained in a SIP commitment. However, States with SIP commitments to adopt Stage II may avoid that requirement if they submit adequate substitute measures that are approved by EPA. Stage II is a viable option for other States that need to develop strategies that will provide sufficient VOC reductions to attain the ozone standard expeditiously. The States that choose to adopt Stage II are free to set efficiency standards, exemption levels, and schedules that meet their VOC reduction needs, based on case-by-case analysis of local conditions. Such specifications would be subject to review and approval by EPA under the SIP processing procedures.

Comment: Several commenters provided recommendations for further studies. Two commenters suggested the field testing of new equipment before mandating its use (I-H-42, I-H-43). One commenter suggested that a comprehensive study be undertaken by a neutral party to determine actual in-use efficiency and cost effectiveness (I-H-82). Another commenter urged EPA to research vapor recovery more fully and, working together with the petroleum industry, to come up with a solution that is acceptable to all parties (I-H-63). One commenter felt EPA should consider other strategies that combine onboard or Stage II with controls on commercial and certification fuels (I-H-114).

Response: As explained in the onboard proposal, EPA believes that there are no problems with the onboard concept that cannot be resolved within the lead-time provided. The principles of vapor recovery are well understood, and onboard is similar to the evaporative control systems that have been on cars for years. Therefore, no long-term testing program, nor a "comprehensive study ... by a neutral third party" is necessary.

As noted earlier, the Agency has evaluated combining control of refueling and controls on commercial and certification fuel volatility, and proposes to regulate both VOC emissions problems.

Comment: A number of commenters made recommendations regarding possible standards. Two commenters expressed concern that the great complexities of VOC emission control may lead to regulations that are either unnecessary (as in the case of areas where there is no threat to the national ambient ozone standard) or so complicated as to be difficult or impossible to implement and enforce (I-H-42, I-H-43). One commenter suggested that EPA proceed with nationwide implementation of Stage I controls because the findings suggest a high risk of cancer through occupational exposure by gasoline handlers (I-H-65). On the other hand, another commenter acknowledged that, while Stage I controls are relatively cost effective in reducing VOC emissions, a nationwide strategy to retrofit Stage I controls would not be cost effective in terms of environmental benefit. (Stage I controls are already largely in place in those areas where the NAAQS is not being attained or in question, and a nationwide program would not be cost effective in attaining national ambient standards or reducing human exposure to gasoline vapors.) (I-H-83).

One commenter stated that they continue to support Stage I vapor recovery as the most cost effective measure for controlling VOC emissions from fuel dispensing facilities (I-H-94). One commenter stated that the installation of additional Stage I equipment is not justified because equipment to control hydrocarbon vapors emitted during loading of truck transports at gasoline terminals and during gasoline deliveries to service stations already is installed in most areas not in attainment with the atmospheric oxidant standard (I-H-99).

Response: As pointed out in Section 10.1, the Agency has not made a determination as to the need to extend coverage of Stage I controls. As some commenters noted, Stage I is presently required in ozone nonattainment areas and is a cost-effective VOC control strategy. The Agency is presently evaluating whether also to require Stage I controls on gasoline marketing facilities in attainment areas, and will announce any proposed decision in the Federal Register.

Comment: One commenter felt the only quick, effective method of addressing a human health hazard from refueling vapors, if one is found to exist, is to equip all service stations with Stage II controls, remove benzene or other hazardous chemicals from commercial gasoline, and reduce the RVP of gasoline to levels that can be more readily handled in the marketing stages and by the vehicle (I-H-101).

Response: As described in the proposed rulemaking, the Agency has decided that onboard control is the most effective solution overall to the refueling emissions problem. The Agency has examined the option of removing benzene from gasoline (I-A-16), but that option is very expensive compared to other alternatives, and would not eliminate benzene tailpipe emissions completely, since benzene is also formed in the combustion process. The Agency has, however, proposed to reduce the RVP levels of commercial gasoline, as suggested by the commenter.

Comment: One commenter believed that more stringent limitations for existing bulk gasoline terminals are obtainable and cost effective. An emission rate of 35 milligrams per liter is obtainable through the use of "polishing" units. This commenter suggested that EPA recommend a 35 mg/liter limit in a revised Control Techniques Guideline (CTG) for existing bulk terminals (I-H-118).

Response: The EPA evaluated add-on or "polishing" units while developing a new source performance standard for bulk terminals. Add-on control systems were found to be unreasonably expensive in this earlier cost analysis [Appendix B in Bulk Gasoline Terminals - Background Information for Promulgated Standards (I-A-44)].

Comment: One commenter pointed out that EPA is considering three facets of the need to control refueling vapors: very uncertain health effects, the known nonattainment of ozone standards, and an evaporative issue related to commercial fuel characteristics. The commenter stated that EPA should be most interested in those solutions that directly attack the known problems, under the conditions of lowest uncertainty. The commenter stated that if EPA feels compelled to control refueling vapors, then the solution is Stage II control in nonattainment areas and control of the volatility of commercial fuel. The commenter felt that this answer deals most directly with the known, understood issues, while avoiding the controversy over uncertain issues (I-H-100).

Another commenter strongly urged the Agency to limit any vapor recovery regulation to the "selected nonattainment areas" as discussed in the July 1984 Analysis Report, Chapter 4 and Table 7-22, which emphasizes the dramatic cost effectiveness advantage of so limiting the requirement (I-H-94).

Response: The Agency has not taken the narrow views espoused by the commenters, but rather has examined the full range of known and potential problems associated with the refueling issue and the potential benefits to be realized from control. This examination included a careful consideration of the uncertainties involved. As a result, EPA proposes control of refueling emissions with onboard technology, and proposes to reduce the volatility of commercial gasoline. The basis for these decisions, including reduction of ozone levels in nonattainment areas, reduction in VOC/ozone transport, maintenance of acceptable ozone air quality levels, and reduction in nationwide cancer risks, is thoroughly explained in the applicable Federal Register notices.

Comment: One commenter suggested that EPA establish a national program using onboard controls as soon as possible rather than continue with a piecemeal program based on Stage II controls. The commenter claimed that 53 percent of all gasoline sold would be exempt from Stage II controls since it would be sold at stations selling less than 50,000 gallons per month, which are exempted by the Clean Air Act (I-H-130).

Response: The rationale for adopting onboard controls is thoroughly described in the proposed rulemaking. The following addresses an apparent misinterpretation by the commenter. The EPA analysis shows that 54 percent of all service stations (both independents and nonindependents) have a throughput of less than 50,000 gallons/month; however, they are not all exempted by the Clean Air Act. Only independent service stations with a throughput of less than 50,000 gallons/month are exempted under Section 324 of the Act. The analysis indicates that approximately 80 percent of independent stations have a throughput of less than 50,000 gallons/month and would, therefore, be exempt from Stage II controls. Section 324 does not provide for specific exemptions of non-independent service stations.

Comment: One commenter strongly urged the Agency to limit any vapor recovery regulation to the "selected nonattainment areas" as discussed in the July 1984 analysis, Chapter 4 and Table 7-22, which emphasizes the dramatic cost effectiveness advantage of so limiting the requirement (I-H-94).

Response: The nonattainment areas described in the tables in Chapter 4, Table 7-22, and in the revised analysis are only examples constructed so that the impacts of controls on various groupings of nonattainment areas could be examined. The purpose of these groupings was not to select a particular grouping as the target for refueling controls.

Comment: One commenter stated that EPA should not require implementation of a dual program. This commenter stated that Stage II vapor recovery at fuel dispensing facilities will not provide sufficient VOC emission reductions to warrant use as an interim measure during the gradual phase-in of enhanced onboard controls through vehicle fleet turnover. The commenter stated that the total cost of a control program to reduce VOC emissions from motor vehicle fueling using a dual program approach would be unreasonable when compared to the costs and benefits of implementing either of the two program options independently. This commenter stated that the cost effectiveness of Stage II will be significantly less if considered an interim measure since the full cost of capital investments must be allocated to the reduced VOC emission reductions realized prior to the obsolescence of the control program. The commenter pointed out that to avoid undue economic hardship, the Clean Air Act provides for control requirements for Stage II to be phased in over at least a 3-year period and provides exemptions for small volume marketers. The commenter felt that this would delay VOC emission reduction benefits and would reduce the effectiveness of Stage II controls as an interim measure during enhanced onboard control phase-in (I-H-92).

Response: The Agency, as noted, has decided not to propose a dual program of onboard with Stage II as an interim measure. However, States with SIP commitments will be required to fulfill those commitments, either by carrying out Stage II or developing acceptable substitute measures consistent with VOC reduction needs. As the commenter points out, the efficacy and reasonableness of Stage II as an interim measure depend in substantial part on how long it will take to complete installation of the system in a given area.

Comment: One commenter felt that there is no legal basis in the relevant sections of the Clean Air Act for the "significant risk" hurdle that EPA has purportedly asserted must be cleared before regulatory action may be taken against cancer-causing pollutants. In the commenter's view, EPA has amassed sufficient evidence of a serious public health hazard that it must act now. This commenter stated that the risks to the individual and the level of incidence pass any conceivable "significance" hurdles EPA might wish to fashion and, accordingly, EPA must establish control requirements for all source categories in the gasoline marketing system (I-H-115).

Response: This commenter argues that the legislative history of Section 112 does not support EPA's "significant risk" test. The EPA disagrees.

The definition of "hazardous air pollutant" was amended in 1977. P.L. 95-95, 91 Stat. 791 §401(c). The legislative history of the amendment shows that it permits EPA to use a "significant risk" test. The purpose of the amendment was to codify the approach to health risks in *Ethyl Corp. v. EPA*, 541 F.2d 1 (D.C. Cir. 1976), *cert. denied* 426 U.S. 941 (1976). As the Committee Report states:

> In summary, the committee's action is intended to support the views expressed in . . . the *Ethyl* case . . . The committee's bill would also apply this interpretation to *all other sections of the act relating to public health protection* [including section 112].

H.R. Rep. No. 95-294, 95th Cong., 1st Sess. 49 (1977) (emphasis added). The House Report reflects Congress' intent. The Conference Committee adopted the House bill without any relevant change or comment; there was no comparable provision in the Senate bill. H.R. Rep. No. 95-564, 95th Cong., 1st Sess. 183-184 (1977) (Conference Report).

The *Ethyl* case plainly states that a finding of "significant risk" is an appropriate test for regulating:

> The Administrator . . . interpret[ed] "will endanger" to mean "presents a significant risk of harm." 541 F. 2d at 13;
>
> . . . the threatened harm must be sufficiently significant to justify health-based regulation of national impact.
> *id.* at 18 n. 32;

> . . . a "danger" . . . can be regulated when the harm to be avoided is widespread lead poisoning and the risk of that occurrence is "significant."
> id. at 20;
>
> . . . regulation was justified because the aggregate was dangerous, and because leaded gasoline was a significant source that was particularly suited to ready reduction.
> id. at 30 (emphasis in original);
>
> [U]nder the cumulative impact theory emissions must make more than a minimal contribution to total exposure in order to justify regulation . . . We accept the Administrator's determination that the contribution must be "significant" before regulation is proper.
> id. at 31 n. 62;
>
> We believe the Administrator may regulate . . . when he determines, based on his assessment of the risks . . . as guided by the policy judgment inherent in the statute, that [the] emissions . . . cause a significant risk of harm to the public health.
> id. at 31-32 (Footnotes deleted throughout).

Moreover, the Committee Report makes clear that Congress was specifically adopting the significant risk test upheld in Ethyl:

> In Ethyl . . . [the court] was called upon to review regulations promulgated by the Administrator . . . to protect the public health from what he found was "a significant risk."
> H.R. Rep. No. 95-294, Supra, at 43;
>
> After reviewing in detail for 25 pages the rationale for the Administrator's judgment that lead in gasoline did present a significant risk of harm, the Court concluded that the Administrator had "handled an extraordinarily complicated problem with great care and candor."
> id. at 47;
>
> The committee's purposes . . . may be summarized as follows: . . . to authorize the Administrator to weigh risks . . .
> id. at 49;
>
> In upholding . . . Ethyl, the committee is moving in a direction which is consistent with most judicial interpretations of the act. Most other courts have held that a substantial element of judgment, including making comparative assessment of risks, . . . are necessary and permissible under the act . . .
> id. at 50;

> . . . [T]he committee language is intended to emphasize the necessarily judgmental element in the task of predicting future health risks of present action and to confer on the Administrator the requisite authority to exercise such judgement.

id. at 51.

10.3 REFERENCES (Comment letters are not repeated here. See Chapter 1, Table 1-1, for a complete list of comment letters.)

I-A-16 Cost of Benzene Reduction in Gasoline to the Petroleum Refining Industry. U.S. EPA. Research Triangle Park, N.C. EPA-450/3-78-021. April 1978.

I-A-44 Bulk Gasoline Terminals - Background Information for Promulgated Standards. U.S. EPA. Research Triangle Park, N.C. EPA-450/3-80-038b. August 1983.

I-G-7 Control of Air Pollution from New Motor Vehicles and New Motor Vehicle Engines: Certification and Test Procedures. U.S. EPA. 46 FR 21628. April 13, 1981.